JPL D-25647

James Webb Space Telescope (JWST)

Mid-Infrared Instrument (MIRI)

DEWAR SUBSYSTEM SPECIFICATION

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CHANGE LOG

Section	Changed by	Date	Change
All	R. Sugimura	3/12/04	Initial Release, for Dewar RFP

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1 SCOPE

This specification defines the requirements for the performance, design, development, verification and delivery of the Mid Infra-red Instrument (MIRI) Dewar Subsystem, which is part of the MIRI System to be flown on the James Webb Space Telescope (JWST).

1.1 PRECEDENCE

Conflicts arising between the requirements of this specification and the requirements of any document referenced herein shall be referred to the JPL contracting official for resolution.

1.2 BACKGROUND

The MIRI is one of three instruments on the James Webb Space Telescope. The MIRI Optics Module (OM) and Dewar are mounted separately within the JWST Integrated Science Instrument Module (ISIM) (see Figure 1.2-1). The ISIM provides all the instruments with a thermal environment of between 35K and 40K through passive cooling.

The MIRI OM includes three Focal Plane Modules (FPMs) which must be cooled to <6.9K during nominal operations. In addition, the majority of the optical components and their local environment must be cooled to below 15.5K to limit detector background noise.

1.3 FUNCTIONAL DESCRIPTION

The MIRI Dewar subsystem provides the needed additional cooling to the MIRI OM. In order to ease interface problems and allow for easy instrument access and easier packaging, the so-called warm launch option for MIRI was selected. The entire MIRI OM remains warm until JWST deployment, after which it is passively cooled along with the other ISIM instruments. When the temperature reaches a certain value (nominally 70K), heat switches located within the Dewar close and provide two independent conductive paths to the tank(s). The MIRI OM is cooled by the Dewar through high thermal conductance straps provided by the OM developer attached to the Dewar at two independent Thermal Strap Interfaces (TSIs). There are two heat-straps to the dewar, each connected by a heat switch to the cryogen tank(s). These switches are located inside the Dewar Vacuum Vessel.

The Dewar Subsystem described in this specification provides a Thermal Strap Interface (TSI) temperature of less than 6.65 K for cooling the MIRI Focal Plane Modules (FPMs), and a TSI temperature of less than 14 K (baseline is 7.6K) at the interface for cooling the Optical Assembly (OA) (as shown in Figure 1.3-1). As mentioned above, the Dewar Subsystem also provides some of the initial, post launch cooling of the OM (Optics and FPMs) from about 70K to their operating temperatures.

The Dewar sensors and functions are controlled by the Dewar Control Electronics (DCE). The DCE interfaces with both the Spacecraft Command and Telemetry Processor (CTP) for launch and other critical functions and the ISIM Command and Data Handling (IC&DH) for routine telemetry and commands.

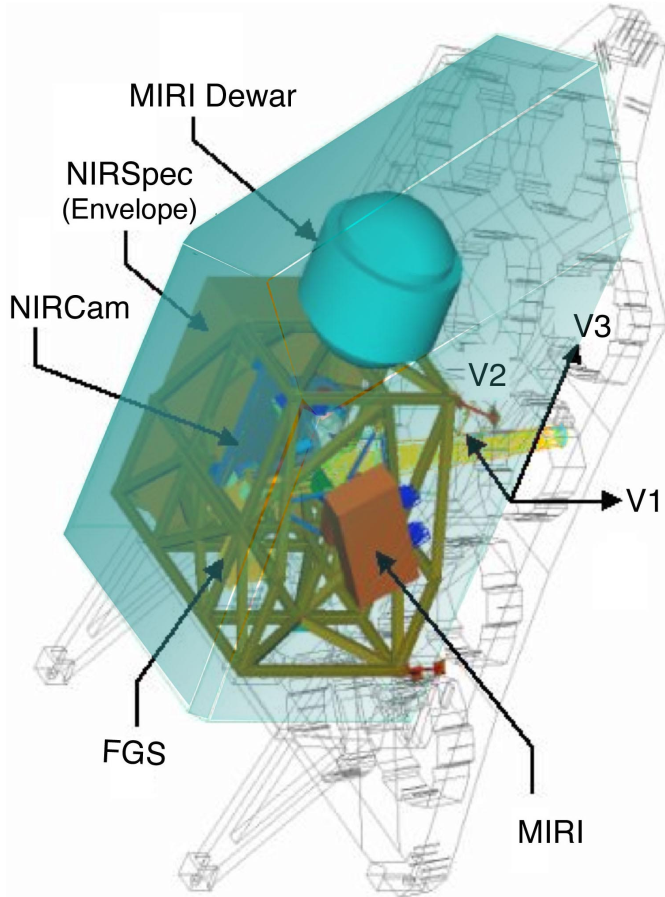


Figure 1.2-1. MIRI OBA and Dewar mechanical mount locations on the ISIM

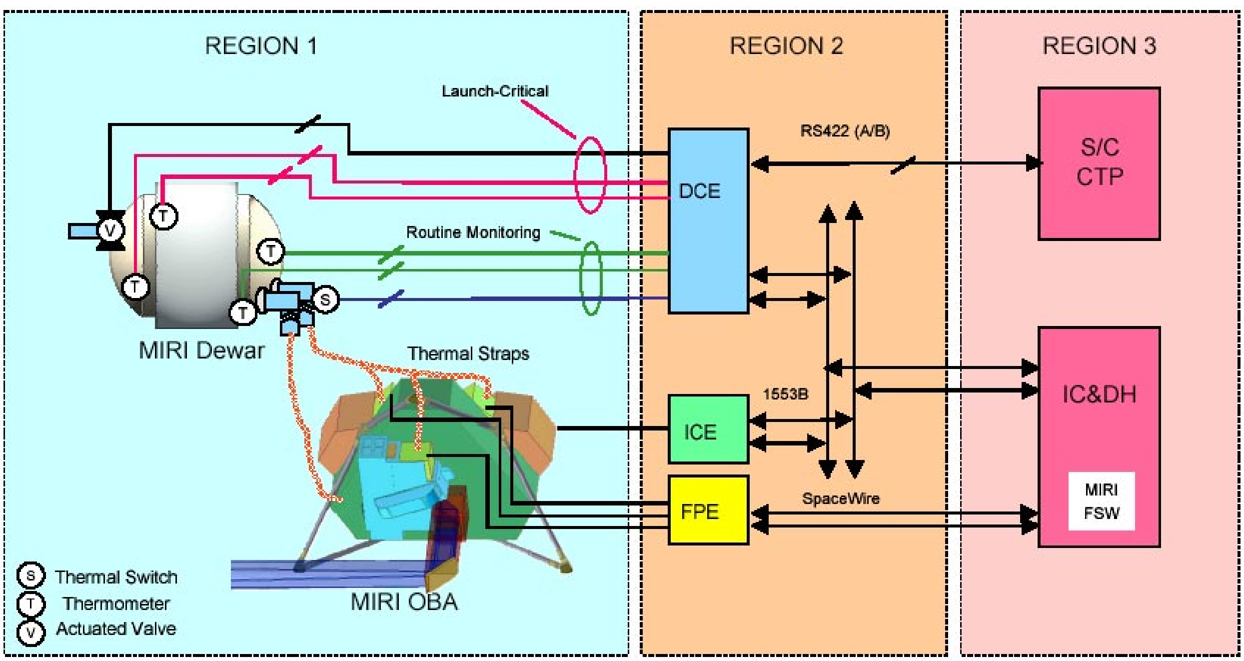


Figure 1.3-1. Functions and interfaces of the assembled Dewar

1.4 DEWAR SUBSYSTEM

The overall MIRI Dewar Subsystem is partitioned into a Dewar Assembly, the Dewar-DCE (GFE) harness and the Dewar Control Electronics.

1.4.1 Dewar Assembly

The Dewar Assembly consists of a Dewar Vacuum Vessel (DVV), the Cryogen Tank(s), any necessary MLI or other thermal shields, two Thermal Strap Interface (TSI) attachment points (cold-buttons) for the MIRI OM provided high conductivity thermal straps, thermal Heat Switches, the external Plumbing Assembly, and the mechanical mounts to support the Dewar off of the ISIM. When the Dewar Vacuum Vessel, Cryogen Tank(s), Strap Thermal Interfaces, Heat Switches, the Plumbing Assembly, etc. are integrated into a single unit, it is referred to as the Dewar Assembly. The Dewar Assembly will be mounted on the upper end of the ISIM Structure inside the ISIM enclosure. The nominal operational environment of the ISIM Structure and Enclosure is 37K.

1.4.1.1 Dewar Vacuum Vessel

The DVV houses all portions of the Dewar Assembly that will be at cryogenic temperatures at launch and will provide vacuum isolation for these items. These items include the Cryogen tank(s), the Heat Switches, internal plumbing, any necessary MLI or other thermal shields, and any instrumentation needed. The mechanical mounts between the ISIM and the Dewar assembly will be attached to the DVV. Also located on the outside of the DVV will be the Thermal Strap Interfaces for the attachment of the FPM and OA thermal straps. Finally, the external Plumbing Assembly will be mounted off of the DVV.

1.4.1.2 Cryogen Tank(s)

The Cryogen Tank(s) store the cryogen used to cool the MIRI FPMs and the MIRI OA.

1.4.1.3 Thermal Strap Interfaces

The Strap Thermal Interface attachment points are where the two MIRI OM provided high conductivity thermal straps from the FPM and OA connect to the Dewar Assembly. These Interfaces are thermally isolated from the DVV, but mechanically mounted to the DVV. The Interfaces are connected internally to the Dewar cryogen tank(s) through thermal Heat Switches

1.4.1.4 Heat Switches

The thermal Heat Switches isolate the cryogen from the Thermal Interfaces for the OBA during the initial cool down and during any decontamination activities.

1.4.1.5 External Plumbing assembly

External Plumbing Assembly consisting of the pipes and valves associated with filling and venting the Dewar, relief, and thermal acoustic oscillation control devices.

1.4.2 Dewar Control Electronics Assembly

The Dewar Control Electronics (DCE) Reads and controls the Dewar instrumentation including all components for monitoring (sensors) and operation (valves) of the Dewar. Instrumentation or components on the Dewar used just for ground operations may be controlled separately from the DCE through appropriate ground support equipment. The function of the Dewar Control Electronics assembly is to provide control of valve and heater functions, to monitor the status of key performance and safety parameters, and to communicate with the host(s) via either the RS422 (to the Spacecraft) or the MIL-STD-1553B bus (to the ISIM). Generally these control functions will involve both analog and digital circuitry, and supporting software/firmware. Additional important functions of the Dewar Control Electronics assembly is to convert, condition, switch, and distribute incoming 28 V S/C power, and furnish it in the correct form to control the various elements of the DCE assembly. For the flight application the electronics shall be fully redundant. The Dewar control electronics is located in ISIM Region 2, at a nominal operating temperature between 273 to 313 K.

1.4.2.1 Flight Cables

All flight cables external to either the Dewar or DCE will be provided as GFE by GSFC, including mating connectors: RS 422 -DCE to S/C-CTP; 1553 – DCE to ICDH, and DCE to Dewar. The Dewar–DCE Harness is a multi-segmented, multiple-conductor cable. The segment from the DCE to an interconnect panel (ICP) will be provided (GFE). The segment from the ICP to a connector on the outside of the DVV wall will be provided (GFE). All portions of the harness after the connector on the DVV (internal or external to the DVV) shall be provided by the contractor (see Figure 1.3-1).

1.5 DEFINITIONS

Dewar Control Electronics (DCE)

Integrates physically with the ISIM, and electrically with the Dewar, ISIM, and S/C, including power conditioning, control and sensing circuitry, spacecraft command and data handling interface circuitry, and firmware. The DCE shall be subjected to Protoflight level testing; it is the actual flight unit for the MIRI Instrument. Qualified flight electronics and cables shall be provided in accordance with the Specification. Cabling between the DCE and Dewar will be provided by JWST, in accordance with the contractor-generated cable specification.

Note: The contractor may want to supply vacuum-rated test cabling as required to check out the Dewar subsystem.

Flight Model Dewar

Includes the Dewar Vacuum Vessel (DVV), ISIM Support interface hardware, heat switches, cryogen fill and vent accommodations, launch-hold and filling equipment (He connection to external dewar, connections for launch-hold guard if necessary, etc.), launch guard (as required), MLI, instrumentation sensors, harness, and connectors. The FM shall be subjected to Protoflight level testing; it is the actual flight unit for the MIRI Instrument. All cabling routed internally to the Dewar shall be vacuum rated and provided by the Contractor.

Pre-Launch Ground Support/Handling Equipment

Ground Support Electronics (GSE) including laboratory electronics and software for operations testing and validation of requirements; cryo-service support hardware including fill and vent lines, helium cooling loop, if needed, for pre-launch operations, software, and electronics for use during service and maintenance of the Dewar Subsystem; Ground-support hardware including, but not limited to, mechanical support equipment for handling, transportation, storing, proof-test, and installation fixtures. Note: some GSE is provided by GSFC (as stated in the Contract)

Engineering Test Unit Dewar (ETUD)

The Dewar structure with respect to form, fit, and function (launch vibration test, center of gravity, mass distribution, etc.); thermal within tolerances as given in the Specification, including heat switches, and vent valve mass (valves need not be functional). Primary function will be to verify the thermal and launch vibration integrity of the ISIM and MIRI instrument interface design with the MIRI detector array and the ISIM. The ETUD shall be delivered with fill and vent accommodations, as required. Laboratory electronics for instrument and control in the form of temperature sensors and heaters (TBR) are to be provided if needed. Interconnecting non-flight cables may be utilized and shall be vacuum rated. Cabling attached to the ETUD shall be vacuum rated and include vacuum feed-through connectors located TBD from the ETUD, be a minimum of TBD meters in length and shall not adversely affect simulated ETUD performance.

Structural Thermal Model Dewar Control Electronics (STM DCE)

Primary function will be to validate the ISIM performance. The Contractor shall provide an electronics STM that utilizes vacuum-rated parts that are physically and thermally identical to the flight hardware as described in the specification. The STM DCE electronics shall include a heater and temperature sensors as necessary to replicate the flight electronics thermal load on the ISIM

1.6 ACRONYMS

ACS	Attitude Control System
AD	Applicable Document
ADOC	After Date of Contract
AIDS	Assembly and Inspection Data Sheet
AIV	Assembly, Integration and Verification
AJRC	After Receipt of JPL’s Review Comment
ANSI	American National Standards Institute
AR	Acceptance Review
ARTM	Anomaly Resolution Team Manager
ASQC	American Society for Quality Control
ASTM	American Society for Test and Materials

ATS	Automated Test Sequence
BAT	Bench Acceptance Test
BE	Breadboard Electronics
BOL	Beginning of Life
BW	BandWidth
C	Centigrade
C&DH	Command and Data Handling
C&T	Command and Telemetry
CCB	Configuration Change Board
CCR	Configuration Change Request
CD	Compact Disk
CDR	Critical Design Review
CDRL	Contract Document Requirements List
CM	Center of Mass/ Configuration Management
CMO	Configuration Management Office
CMOS	Complimentary Metal on Semiconductor
COTS	Commercial Off-The-Shelf
CPT	Comprehensive Performance Test
CPU	Central Processing Unit
CRB	Configuration Review Board
CSA	Canadian Space Agency
CSE	Cryogenic Service Equipment
CTE	Coefficient of Thermal Expansion
CTP	S/C Command and Telemetry Processor
DCE	Dewar Control Electronics
DDR	Detail Design Review
DHE	Dewar Housekeeping Electronics
DILS	Data Items List and Schedule
DMGSER	Developmental Models and Ground Support Equipment Requirements
DOORS	Dynamic Object Oriented Requirements System

DPA	Destructive Physical Analysis
DRD	Data Requirements Description
DS	Detector System (= FPMs + FPE + harness).
DSN	Deep Space Network
DVM	Design, Verification, Manufacture
DVV	Dewar Vacuum Vessel
EA	Electronics Assembly
EC	MIRI European Consortium
ECR	Engineering Change Request
EEE	Electrical, Electronic, and Electromechanical (EEE) Parts
EGSE	Electronic Ground Support Equipment
EICIT	Electrical Interface Continuity/Isolation Test
ELDRS	Extreme Low Dose Susceptibility
ELU	Electronics Unit
EM	Engineering Model
EMC	Electromagnetic Conductance
EMI	Electromagnetic Interference
EOL	End of Life
EPA	Environmental Protection Agency
ESA	European Space Agency
ESD	Electrostatic Discharge
ETU	Engineering Test Unit
FA	Flight Acceptance
FDF	Flight Dynamics Facility, Flight Data File
FDS	Flight Dynamics System
FDSS	Flight Data System Software
FEM	Finite Element Model
FGS	Fine Guidance Sensor
FLAGRO	Fatigue Crack Growth Computer Program
FM	Flight Model

FMECA	Failure Modes and Effects Analysis
FOR	Flight Operations Review
FOT	Flight Operations Team
FOV	Field Of View
FPM	Focal Plane Module
FPA	Focal Plane Assembly
FPE	Focal Plane Electronics
FPM	Focal Plane Module
FRB	Failure Review Board
FRD	Functional Requirements Document
FRR	Flight Readiness Review
FS	Factors of Safety
FSW	Flight Software
FTA	Fault Tree Analysis
FWHM	Full Width at Half Maximum
Gbytes	Gigabytes
GDS	Ground Data System
GIDEP	NASA and Government Industry Data Exchange Program
GFE	Government Furnished Equipment
gm	Gram
GN	Ground Network
GPTS	Ground Power Test Set
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
GTS	Ground Test System
HRCR	Hardware Review and Certification Review
Hz	Hertz
I&T	Integration and Test
I/F	Interface
IC&DH	ISIM C&DH

ICD	Interface Control Document
ICE	Instrument Control Electronics
ICES	Instrument Control Electronics Simulator
ICWG	Interface Control Working Group
IDT	Instrument Development Team
IGSE	Instrument Ground Support Equipment
IIN	Instrument Identification Number
IM	Instrument Manager
IMS	Information Management System
IMT	Integrated Mission Timeline
ions/cm2	Ions per Square Centimeter
IOT	Instrument Operations Team
IOU	Instrument Operations Understanding
IP	Instrument Provider
IPG	Instrument Planning Group
IR	Inspection Report
IR	InfraRed
IRD	Interface Requirements Document
ISIM	Integrated Science Instrument Module
ISS	ISIM Shared Services
IST	Instrument Support Terminal, Instrument Science Team
ITAR	International Traffic In Arms Regulations
IWG	Investigator Working Group
JPIP	Joint Project Implementation Plan
JPL	Jet Propulsion Laboratory
JWST	James Webb Space Telescope
K	Kelvin
Kg	Kilogram
KM	Kinematic Mounts
Krad	Kilo Rad, A Unit of Absorbed Dose

L&EO	Launch and Early Orbit
L2	Second Lagrangian Point
LET	Linear Energy Threshold
Linux	UNIX Type Computer Operating System
LLIS	NASA Lessons Learned
LOA	Letter Of Agreement
LRR	Launch Readiness Review
Ltd	Limited
m	Meter
M & P	Materials and Processes
MAM	Mission Assurance Manager
MAP	Mission Assurance Plan
MAR	Mission Assurance Requirements
Mbps	Megabits per second
Mev-cm2/mg	Million Electron Volts per square centimeter per milligram
MGSE	Mechanical Ground Support Equipment
MIL	Military
MIRI	Mid Infrared Instrument
MIUL	Materials and Identification Usage List
MLI	Multi Layer Insulation
mm	Millimeter
MOR	Mission Operations Review
MOSFET	Metal Oxide Semiconductor Field Effect Transistor
MOU	Memorandum of Understanding
MOWG	Mission Operations Working Group
MRB	Material Review Board
MRR	Manufacture Readiness Review, Mission Readiness Review
MST	MIRI Science Team
MT	Mission Test
MUA	Materials Usage Agreement

NAR	Non Advocate Review
NASA	National Aeronautics and Space Administration
NASTRAN	NASA Structural Analysis
NCC	Network Control Center
NCR	Non Conformance Report
NDE	Nondestructive Evaluation
NDI	Nondestructive Inspection
NGST	Northrop Grumman Space Technology
NIRCam	Near Infrared Camera
NIRSpec	Near Infrared Spectrograph
NO	Non-Operating
NPSL	NASA Parts Selection List
NRB	Nonconformance Review Board
NRT	Near Realtime
NSPAR	Nonstandard Parts Approval Request
OA	Optics Assembly (OM – FPMs)
OBA	Optical Bench Assembly (OA + FPMs+ICE+FPE)
OCD	Operations Control Document
OM	Optics Module (OA+FPMs: everything in Region 1)
OP	Operating
ORR	Operations Readiness Review
OTE	Optical Telescope Element
PB	Playback
PCP	Parts Control Plan
PDF	Portable Data Format
PDR	Preliminary Design Review
PDS	Product Delivery System
PDS	Production Data Set
PDU	Power Distribution Unit
PER	Pre-Environmental Review

PFR	Problem Failure Report
PI	Principal Investigator
PITTR	Pre-Integrated Test Readiness Review
PM	Project Manager
POM	Pick Off Mirror
PRA	Probabilistic Risk Assessment
PRF	Preferred
PSA	Parts Stress Analysis
PSF	Point Spread Function
PSR	Pre-Ship Review
PTR	Post Test Review
QA	Quality Assurance
QAR	Quality Assurance Representative
QCM	Quartz Crystal Microbalance or Quality Control Monitor
QLA	Quick Look Analysis
QML	Qualified Materials List
QPL	Qualified Parts List
RAD	A Unit of Absorbed Dose
RAL	Rutherford Appleton Laboratory
RAM	Random Access Memory
RBD	Rate Buffered Data
RD	Reference Document
RFD	Request For Deviation
RFP	Request for Proposal
RFPs	Request for Proposals
RLAT	Radiation Lot Acceptance Testing
RMS	Root Mean Square
RQMT	Requirement
RSS	Root Sum Square
S/C	Spacecraft

SAR	Spacecraft Anomaly Resolution
SC	SpaceCraft
SCA	Sensor Chip Array
SCC	Stress Corrosion Cracking
SEB	Single Event Burnout
SEE	Single Event Effects
SEGR	Single Event Gate Rupture
SEL	Single Event Latchup
SET	Single Event Transient
SEU	Single Event Upset
SFPs	Single Point Failures
Si	Silicon
SI	Systeme Internationale
SIDU	Science Instrument Development Unit
SIIS	Spacecraft Instrument Interface Simulator
SIITS	Science Instrument Integration Test Sets
SINDA85A	
SIS	Stored Instruction Sequence
SITS	Science Instrument Test Set
SNR	Signal to Noise Ratio
SOI	Silicon on Insulator
SOS	Silicon on Sapphire
SOW	Statement of Work
SRD	Science Requirements Document
SSM	Spacecraft Support Module
SSR	Solid State Recorder
STM	Structural Thermal Models
STP	Special Test Procedures
STR	Sample Test Review
STScI	Space Telescope Science Institute

SW	Software
T/V	Thermal Vacuum
TAA	Technical Assistance Agreement
TBC	To Be Confirmed
TBD	To Be Determined
TBR	To Be Resolved
Tbytes	Terabytes
TCTS	Telemetry Command Test Set
TID	Total Ionizing Dose
TIM	Technical Interchange Meeting
TL	Team Leader
TML	Total Mass Loss
TPRR	Technical Problem Resolution Request
TQCM	Temperature Quartz Crystal Microbalance
TRASYS	Thermal Radiation Analyzer System
TRP	Temperature Reference Point
TRR	Test Readiness Review
TSI	Thermal Strap Interface
US	United States
UV	Ulta Violet
V	Volts
VCE	Collector/Emitter Voltage
VCM	Volatile Condensable Mass
VDS	Drain/Source Voltage
VGS	Gate/Source Voltage
VM	Verification Model
WCA	Worst Case Analysis

2 APPLICABLE DOCUMENTS

The following documents, of the issue specified in the contractual instrument, form a part of this specification to the extent specified herein.

Number	Title
	Ariane 5 Users Manual, March 2000 Edition
CSG-RS-10A-CN	Centre Spatial Guyanais (CSG) Safety Regulations Vol. 1: General Rules
CSG-RS-21A-CN	CSG Safety Regulations Vol. 2 Pt. 1: Specific Rules: Ground Installations
CSG-RS-22A-CN	CSG Safety Regulations Vol. 2 Pt. 2: Specific Rules: Spacecraft
ANSI X3. 9	Programming Language Fortran, Information Systems
ANSI X3.159	Programming Language C, Information Systems
ASTM E595-93	Total Mass Loss and Collected Volatile Condensable Materials
IEEE/ASTM SI 10	Standard for Use of the International System of Units (SI), 1997
ISO 14644	Cleanrooms and controlled environments, Part 1-and Part 2
JPL CS515574	Hybrid Integrated Circuit, Crystal Oscillator
JPL D- 560	JPL Standard for Systems Safety
JPL D-1348	Electrostatic Discharge
JPL D-8208	Electronic Packaging and Cabling - Spacecraft Design and Fab. Req’ts.
JPL D-8545	JPL Derating Guidelines
JPL FS507017	Identification and Marking Methods for Parts and Assemblies
JPL-STD-00009	Flight Materials, Processes, Fasteners, Packaging and Cabling Selection
MIL-PRF-19500	Semiconductor Devices, General Specification for
MIL-PRF-38534	Hybrid Microcircuits, General Specification for
MIL-PRF-38535	Integrated Circuits (Microcircuits) Manufacturing
MIL-PRF-39003	Capacitors, Fixed, Electrolytic (Solid Electrolyte), Tantalum
MIL-PRF-55365	Capacitor, Fixed, Electrolytic (Tantalum), Chip
MIL-STD- 461C	Requirements for the Control of Electromagnetic Interference
MIL-STD- 462	Measurement of Electromagnetic Interference Characteristics
MIL-STD- 883	Test Method Standard, Microcircuits, latest revision
MIL-STD- 889B	Dissimilar Metals
MIL-STD-1246	Product Cleanliness Levels and Contamination Control Program
MIL-STD-1522A	Safe Design and Operation of Pressurized Missile and Space Systems
MIL-STD-1553B	Digital Time Division Command/Response Multiplex Data Bus
MIL-STD-1815	Programming Language Ada, Information Systems
MSFC-HDBK-527	Materials Selection List for Space Hardware Systems
MSFC-STD-3029	Selection of Metallic Materials for Stress Corrosion Cracking Resistance
NASA-STD-5003	Fracture Control Requirements for Payloads Using the Space Shuttle
NPSL	NASA Parts Selection List, at URL http://nepp.nasa.gov/npsl/
QML-19500	Qualified Manufacturers List of Products underMIL-PRF-19500

QML-38534	Qualified Manufacturers List of Custom Hybrid Microcircuits
QML-38535	Qualified Manufacturers List of Advanced Microcircuits
SSQ 25000	Destructive Physical Analysis (DPA) Testing for Space Station
JWST-RPT-000453	Radiation Environment for the James Webb Space Telescope
JPL D-25631	MIRI Mission Assurance Plan

3 REQUIREMENTS

3.1 MODES OF OPERATION

The Dewar Subsystem shall implement the following operational modes as required to interface with the spacecraft, the ISIM, and the MIRI instrument, and to carry out its various functions. Modes of operation shall include:

3.1.1 Off Mode

During Off Mode, MIRI shall receive no power from the spacecraft other than survival power to prevent damage to the electronics.

3.1.2 Survival Mode

During Survival Mode, MIRI shall reconfigure as necessary to prepare for a transition to Off Mode. Survival power will be provided by the ISIM/Spacecraft to prevent under-temperature conditions.

3.1.2.1 Survival Heater Power

Dewar Region 1 survival heater power, if determined to be necessary, shall be documented in the Dewar-MIRI ICD, including all survival heater characteristics (mounting location, attachment details, power, etc.).

3.1.3 Operational Mode

The MIRI operational mode will carry out all programs necessary to meet its science requirements, as defined in JPL D-24157, "MIRI Scientific Requirements Document." Intermediate instrument submodes shall be defined as necessary to facilitate the startup and initialization of all MIRI subsystems, transitions to different observation reconfigurations, calibration, maintenance, and diagnostics.

The following are a subset of the Operational Mode:

3.1.3.1 Standby Submode

When power is first applied, all secondary subsystems are powered on, including the Dewar Control Electronics that shall enter Standby Mode. The Dewar Control Electronics digital communication and control electronics shall be on and the complete data message list shall be available. The relay power driver(s) for heaters and other power drivers shall be in an unpowered state. In the Standby Mode it shall be possible for the Spacecraft to upload set-point parameters and enable other submodes such as opening and closing the Dewar vents, and enable or disable the Dewar heat switches.

3.1.3.2 Mission Submode

The Mission sub-mode is the primary mode for the MIRI system.

3.1.3.3 Cool down and Decontamination Submode

The MIRI cooldown mode shall transition the OBA from 70K to its operating temperature. The Dewar heat switch(es) are designed to close at a temperature at or near 70K, allowing the solid cryogen to sublimate and remove heat from the OBA. The Decontamination mode is a contingency mode only, and it is used to allow the OBA to warm up (either just the pick-off mirror to 40K, or (less likely) the whole OBA to 160K) to remove any accumulated contaminants from the optics if necessary. Heat switches, which provide the means of connecting or disconnecting the Dewar and the load, shall be kept in the open position by control signals issued by the DCE. The Dewar subsystem shall restore the FPM and OBA to its nominal operating temperature and stability specification within TBD days of the end of a decontamination procedure. (Note: This is a separate operation from the Detector Annealing procedure that occurs periodically, raising the detector temperatures to 20K to remove, or anneal, defects caused by cosmic ray impacts. During detector annealing, the Dewar subsystem continues to maintain cooling to the thermal interfaces to the detectors and OBA.)

3.1.3.4 Safe Submode

The MIRI Safe shall be entered on detection of instrument functional anomalies during routine operations or during ISIM/spacecraft anomalies. In Safe Mode, MIRI shall reconfigure as necessary to a state that protects the instrument. In this submode the Dewar subsystem continues to maintain the interface to the detectors and OBA in the same condition/state (heat switches open or closed) as they were when Safe mode was entered.

3.1.3.5 Engineering Submode

The MIRI Engineering mode occurs during the initial phase of the mission while the ISIM is cooling to its operating temperature. The heat switches are kept open during this mode.

3.1.4 S/C Mode Transitions

All MIRI subsystems shall withstand an unannounced transition between any two modes without damage or reduction in capabilities.

3.2 CHARACTERISTICS

3.2.1 Physical Characteristics

The FM Dewar and Dewar Control Electronics assemblies shall be as compact as possible consistent with reasonable cost, efficient and reliable assembly, and access for rework.

3.2.1.1.1 Dewar Configuration

The Dewar configuration shall conform to the size specified in the physical static envelope of the MIRI Dewar Envelope and ISIM Interface Drawing, figure 3.2.1.1.1-1 and 3.2.1.1.1-2, which apply at ambient conditions.

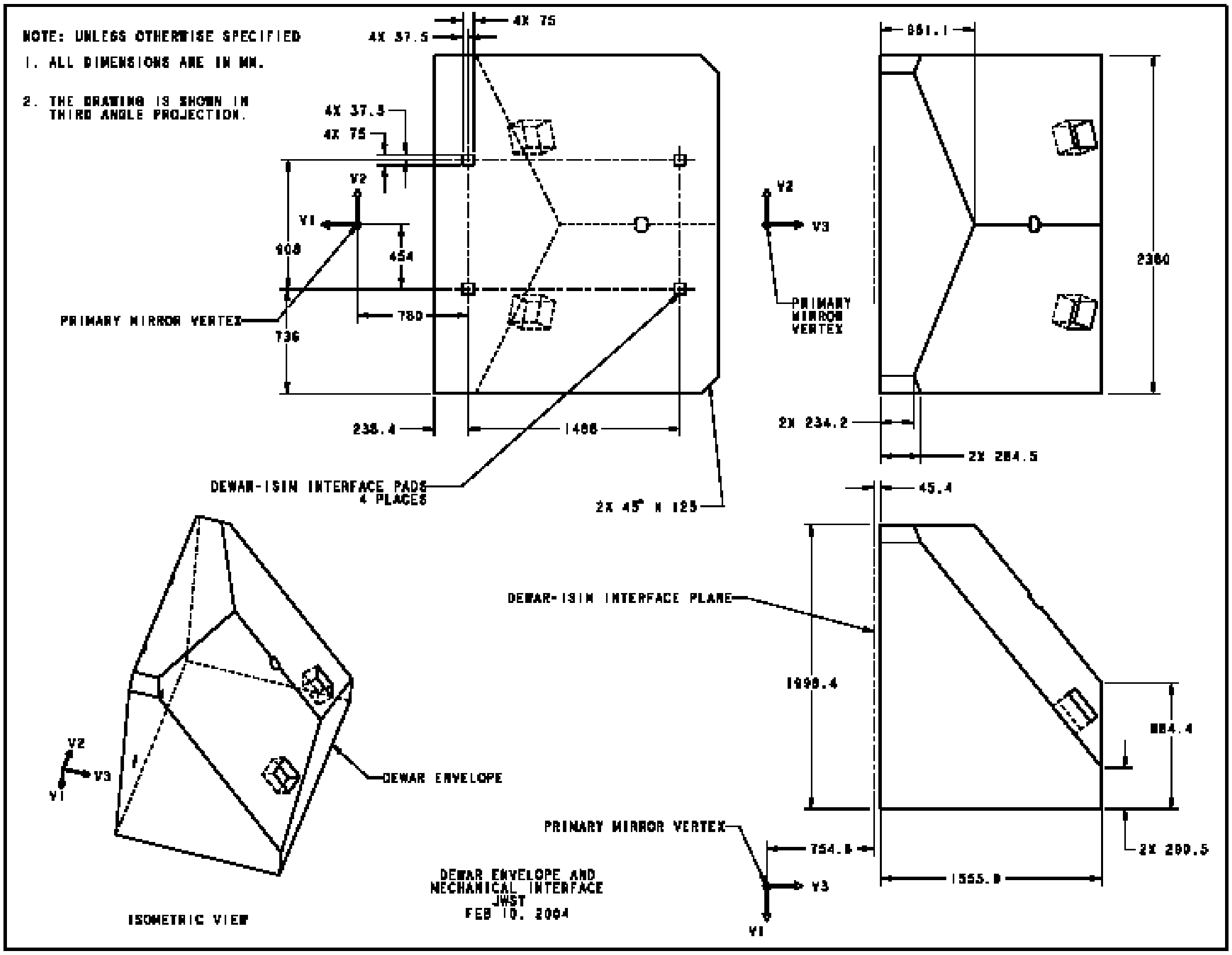


Figure 3.2.1.1.2-1. Physical Envelope of the MIRI Dewar and ISIM mounting locations.

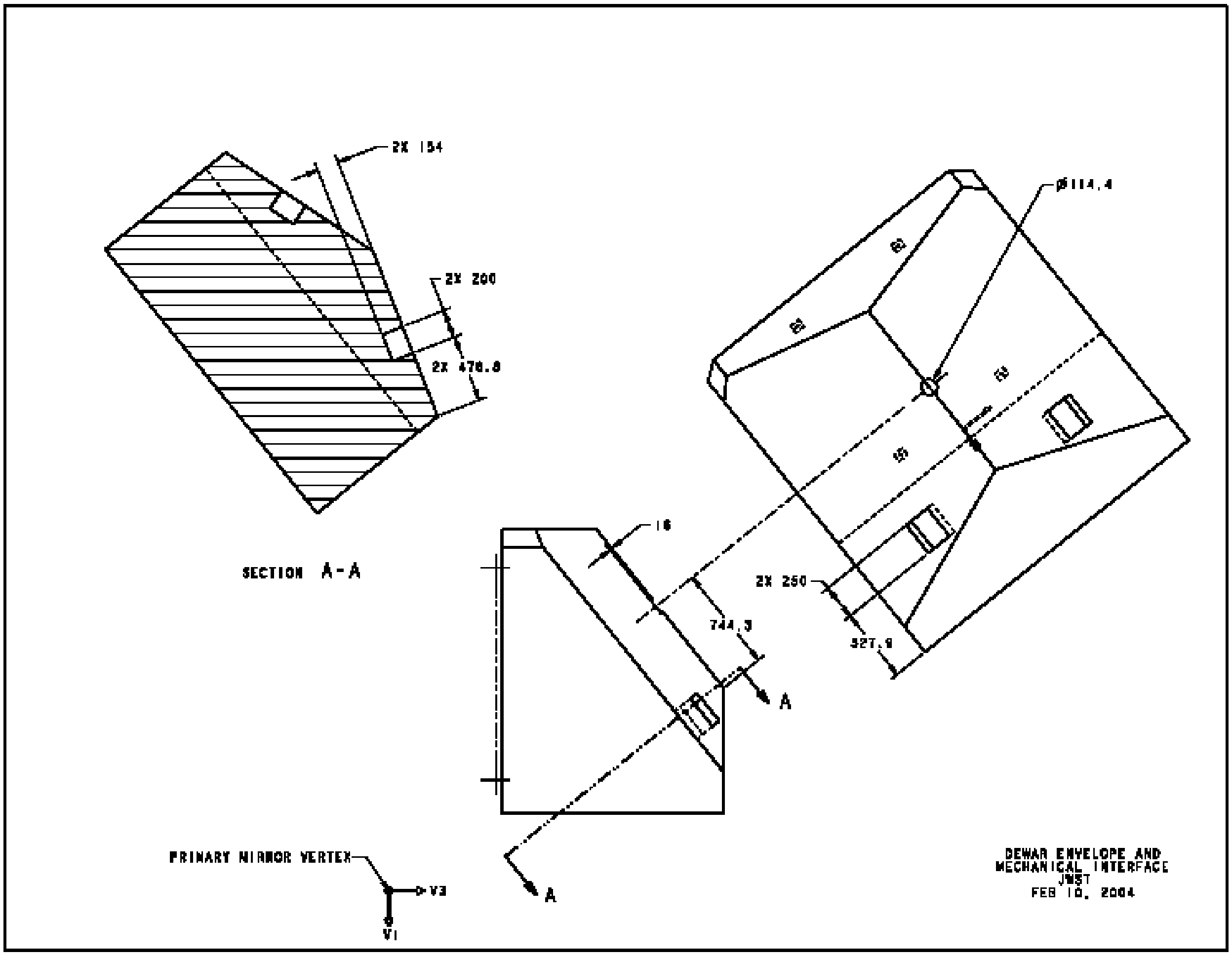


Figure 3.2.1.1.2-2. Physical Envelope of the MIRI Dewar

3.2.1.1.1.1 *Dewar Vacuum Vessel*

The Dewar consists of a Dewar Vacuum Vessel (DVV) that shall be supported off of the ISIM support structure by a set of Dewar-provided mounts.

3.2.1.1.1.2 Cryogen Storage Tanks

The DVV shall contain cryogen storage tank(s) supported by low thermal-conductance means.

3.2.1.1.1.3 Cold Shield

If needed to meet the required launch-hold constraints or for operational performance, a Cooled Shield surrounding the cryogen tanks inside the DVV shall be provided.

3.2.1.1.1.4 Dewar Plumbing

The Dewar design shall provide and allow for the necessary plumbing, harness connections and feed-throughs to accommodate heat switches and straps, fill and vent lines, valves, and coolant lines, as applicable.

The Dewar flight vent valves shall have position sensors (open/closed).

3.2.1.1.1.5 Dewar Component Orientation

The Dewar component orientation and dimensions, including MLI shall be provided to JPL and documented in the Dewar- MIRI ICD as a “not-too-exceed dimension.”

3.2.1.1.1.6 Cold Finger Assembly and Heat Switches

The Dewar cold finger assembly shall contain heat switche(s) and a hermitic feedthrough that thermally isolates the cryogen storage tanks from the outside of the DVV. One end of the cold finger assembly attaches to the cryogen storage tank and the other end terminates in a Thermal Strap Interface (TSI) that constitutes the attachment point for the thermal strap.

3.2.1.1.1.7 Thermal Strap Interfaces

The Dewar assembly shall contain two independent thermal strap interfaces (TSIs), one for the FPM and one of the OA, that connect through heat switches to the cryogen tank(s) and allow for the attachment of thermal straps.

3.2.1.1.1.8 Heat Switches

The Dewar assembly shall contain heat switches that can thermally isolate the cryogen from the OBA until the OBA reaches T<70K (TBR).

3.2.1.1.2 Dewar Control Electronics Configuration

The Dewar Control Electronics component shall fit within an Envelope of the 200mm x 200mm x 200mm (TBR)(HXWXL).

3.2.1.1.2.1 Dewar Control Electronics Location

The Dewar Control Electronics for controlling and monitoring the Dewar shall be mounted in Region 2 of the JWST.

3.2.1.1.2.2 Dewar Control Electronics Connection

The Dewar Control Electronics shall be connected to the Dewar by the cryostat harness.

3.2.1.2 Mass

3.2.1.2.1 Dewar Assembly Mass

The mass of the Dewar Assembly, shall be minimized, within the constraints imposed by the requirements in this specification and including all margins as specified below. The mass of the Dewar Assembly shall be documented in the Dewar – MIRI ICD.

The amount of cryogen shall be sized according to the margined heat load values calculated (Dewar parasitic heat loads) and given (MIRI OBA instrument heat loads). NO additional margin should be applied to calculate the cryogen mass.

Note: Any items that are only sized by the amount of cryogen should not have additional mass margin added. These items may include the cryogen itself, any filler material, and any other non-structural element.

3.2.1.2.2 DCE Assembly Mass

The mass of the Dewar Control Electronics Assembly, including all cards, internal harnessing, and connectors shall be less than 7kg.

3.2.1.2.3 Dewar Component Mass

The mass of each MIRI component shall be measured to an accuracy of 0.2% or +/- 0.1kg, whichever is greater. This includes a measurement of the mass at launch.

3.2.1.3 Orientation

3.2.1.3.1 Dewar Coordinate System

The OTE/ISIM coordinate system is an orthogonal right-handed system, with axes labeled, in order, V1, V2, V3 as shown in Figure 3.2.1.3.1-1. The origin (0, 0, 0) is located at the vertex of the primary mirror surface. The Dewar-ISIM interface lies in the V1-V2 plane at the 754.6mm dimension along the V3 axis as shown in Figure 3.2.1.1.2-1.

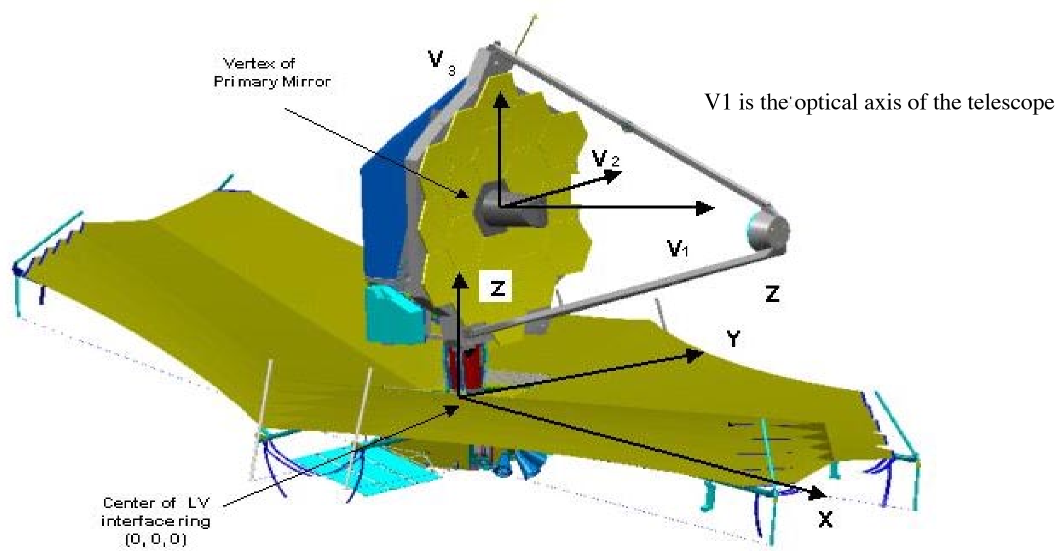


Figure 3.2.1.3.1-1: ISIM coordinate system definition.

3.2.1.3.2 Dewar Installation

The Dewar assembly shall be capable of being installed/removed with the ISIM/SC V3 axis horizontal and the V2 or V1 axis down.

3.2.1.3.2.1 *Dewar Installation During Ground Operations*

The Dewar assembly shall be capable of being installed or removed during ground operations without degradation, damage, or requiring re-certification of the flight hardware.

3.2.1.3.2.2 *Fill Orientation*

The fill orientation for flight will be the +V3 up, the same orientation as the launch orientation given in 3.2.3.1.1.1

3.2.1.3.3 Dewar Center of Gravity

The Dewar center of gravity envelope shall be documented in the Dewar-MIRI ICD.

3.2.1.3.3.1 *Dewar Component Center of Gravity*

The center of gravity of each MIRI Dewar Subsystem component, referenced to its respective coordinate axes (as documented in the Dewar-MIRI ICD), shall be predicted through analysis.

3.2.1.3.3.2 *Dewar Component Center of Gravity Measurements*

The center of gravity of each MIRI Dewar Subsystem component, referenced to its respective coordinate axes (as documented in the Dewar-MIRI ICD), shall be measured in two axes to +/-3mm.

3.2.1.3.3.3 *Dewar Center of Gravity Stability*

TBD

3.2.1.3.3.4 *Dewar Moments of Inertia*

The moments of inertia for each MIRI component, referenced to the MIRI coordinate axes as documented in the Dewar-MIRI ICD shall be predicted through analysis.

3.2.1.3.3.5 *Expected Dewar Moments of Inertia*

Expected MOIs of the MIRI dewar, with the dewar 100% full, 50% full, and empty shall be provided to JPL.

3.2.1.3.3.6 *Maximum Inertia Variations*

The respective maximum inertia variations due to movable masses or expendable masses shall be documented in the Dewar-MIRI ICD

3.2.1.3.4 Dewar Reacted Angular Momentum

TBD

3.2.1.3.4.1 *MIRI Dewar to the ISIM Reacted Angular Momentum*

TBD

3.2.1.3.4.2 *ISIM to the MIRI Dewar Reacted Angular Momentum*

TBD

3.2.1.3.4.3 *DCE Orientation*

Orientation of the Region 2 DCE component shall be negotiated and documented in an ICD provided to JPL.

3.2.1.3.4.4 *DCE Location*

Location of the Region 2 DCE component shall be negotiated and documented in an ICD provided to JPL.

3.2.2 Performance

3.2.2.1 Refrigeration Performance

The Dewar Subsystem shall be capable of stable operation within specification over the range of user-supplied cryogenic refrigeration loading conditions and interface temperatures as described below. In addition to the user-supplied cryogenic loads at the two "cold button" interfaces to the MIR OBA (the FPM "cold button" TSI and the OA "cold button" TSI) the Dewar Subsystem must carry all parasitic thermal loads introduced by the host S/C (ISIM) thermal environment into the Dewar assembly, including any parasitic loads that enter directly into the piping or from the mounting of the "cold buttons" (TSIs) on the outside of the DVV.

3.2.2.1.1 Baseline Operating Point

The Baseline Operating Point is defined as the Dewar at equilibrium with all host (ISIM) thermal interfaces at their Baseline temperatures per Table 3.2.4.3-1, the FPM Thermal Strap Interface (TSI) at a temperature less than 6.65 K with a nominal heat load of 4.8 mW, and the OA TSI at a temperature of less than 7.6 K (TBR) with a load of 55.2 mW (TBR).

NOTE: The heat lift requirements provided in this document from the OBA are margined values, and should not have any additional margin applied. Margin (30%) should be applied to all Dewar calculated parasitic heat loads.

3.2.2.1.2 Baseline Cooling Capacity

The Baseline Cooling Capacity is defined as the cooling capacity under nominal operating conditions with all host (ISIM) thermal interfaces at their Baseline temperatures per Table 3.2.4.3-1 over the Dewar operational lifetime.

The Dewar's FPM TSI shall have a measured Baseline Cooling Capacity with its temperature less than 6.65K with a heat load of 4.7 mW, while the OA TSI interface shall simultaneously have a Baseline Cooling Capacity with its temperature less 7.6 K (TBR) with a heat load of 55.3 mW (TBR).

NOTE: The heat lift requirements provided in this document from the OBA are margined values, and should not have any additional margin applied. Margin (30%) should be applied to all Dewar calculated parasitic heat loads.

3.2.2.1.3 EOL Cooling Capacity

The End-of-Life (EOL) Cooling Capacity is defined as the cooling capacity at the FPM and OA TSIs at the predicted EOL Condition as defined by 3.2.2.5.4 with all host (ISIM) thermal interfaces at their *maximum* Flight Allowable-Operating temperatures per Table 3.2.4.3-1.

The Dewar's FPM TSI shall have a measured EOL Cooling Capacity with its temperature less than 6.65K with a heat load of 4.8 mW, while the OA TSI interface shall simultaneously have a Baseline Cooling Capacity with its temperature less 7.6 K (TBR) with a heat load of 55.2 mW (TBR).

3.2.2.1.4 Baseline Cooldown Starting Condition

Baseline Cooldown Starting Condition (cooldown of the MIRI OBA by the Dewar) is defined as follows:

a. The Dewar assembly thermal interfaces remain at their baseline values in Table 3.2.4.3-1 during the cooldown period

b. At the start of cooldown the cold button interfaces (TSIs) and the OA and FPM cryogenic loads are at 70 K.

3.2.2.1.5 Cooldown Time

The Dewar subsystem shall cool the OA and FPM cold loads down from the Baseline Cooldown Starting Condition to the Baseline Operating Point in less than 5 days (TBR) after closure of the heat switches.

Comment: This cooldown requirement specifies the required flight cooldown performance.

Note: The cooldown performance will be calculated after the Dewar vendor has been selected and the thermal model of the OBA and Dewar have been integrated. Cooldown calculations do not need to be done as part of the RFP response.

3.2.2.1.6 Cooldown

The Dewar subsystem shall provide active control (through activation of the heat switches) to cool the OA and FPM loads from their Baseline Cooldown Starting Condition (70K) to the Baseline Operating Point.

3.2.2.2 Heat Switch Performance

The Dewar Heat switches shall be opened any time during commissioning or operation when commanded from the ground.

3.2.2.2.1 Heat Switch Activation Temperature

The heat switch design shall allow active switching OPEN to CLOSED within the temperature range of the TSI of 140K (TBR) to 6K.

3.2.2.2.2 Heat Switch Conductance (Open and Closed)

The conductance of the heat switches as a function of temperature and of state (Open or Closed) shall be documented in the Dewar-MIRI ICD.

3.2.2.3 Power Consumption

3.2.2.3.1 Baseline Power Consumption

Baseline power consumption is defined as the input power to the Dewar Control Electronics assembly from the 28 V dc bus. The baseline power consumption should be less than 6.0W.

3.2.2.3.2 EOL Power Consumption

EOL Power Consumption is defined as the predicted input power to the Dewar Control Electronics from a 28 V dc bus when the Dewar is in its Predicted EOL Condition as defined by 3.2.2.5.4. The EOL Power Consumption shall be less than 6.0 W.

3.2.2.4 Temperature Sensors and Control

The Dewar instrumentation shall contain sufficient representative temperatures to verify the thermal model, and assess the health and performance of the Dewar over its lifetime.

Comment: The following requirements provide for measuring the cold button interface (TSI) temperatures.

3.2.2.4.1 Temperature Sensors

The Dewar subsystem shall contain redundant temperature sensors mounted on both the OM and FPM cold-button interfaces (TSIs), the cryogen tank(s), and the heat switches for monitoring and assessing the health and performance of the Dewar and the heat switches during the mission.

3.2.2.4.1.1 *Temperature Sensors Range*

The Dewar Subsystem temperature sensors and their readout electronics shall be capable of measuring temperatures in the range from 4 K to 320 K.

3.2.2.4.1.2 Temperature Sensors Resolution

The Dewar subsystem temperature sensors and their readout electronics shall be capable of measuring the temperature with a resolution of less than 0.5mK for the temperature range 4 K to 12 K, a resolution of less than 50mK for the temperature range 12 K to 70 K, and a resolution of 1.0K for the temperature range 70 K to 320 K over the mission duration.

3.2.2.4.2 Temperature Sensors Accuracy

The Dewar Subsystem temperature sensors and their readout electronics shall be capable of measuring temperature with an accuracy ±10mK for the temperature range 4 K to 12 K, an accuracy ±500mK for the temperature range 12 K to 70 K, and an accuracy of ±2.5K for the temperature range 70 K to 320 K over the mission duration.

3.2.2.5 Temperature Stability

Comment: The following requirements apply to Dewar TSI interface temperature stability at the Baseline Operating Point.

3.2.2.5.1 FPM Interface Short-Term Temperature Stability

The Dewar subsystem shall be capable of limiting the variation of the FPM cold-button interface (TSI) temperature to no greater than ±25 mK (TBR) over a 1000-s period, given the Dewar Subsystem thermal interface temperature variations and heat load variations equal to the maximum rates of change defined in 3.2.4.3.2.

3.2.2.5.2 FPM Interface Long-Term Temperature Stability

The Dewar shall be capable of limiting the variation of the FPM cold-button interface temperature to no greater than ±100 mK (TBR) over a 24-hour period, given the Dewar subsystem thermal interface temperature variations and heat load variations equal to the maximum rates of change defined in 3.2.4.3.2.

3.2.2.5.3 OA Interface Short-Term Temperature Stability

The Dewar shall be capable of limiting the variation of the OA cold-button interface temperature to no greater than ±250 mK (TBR) over a 1000-s period, given the Dewar thermal interface temperature variations and heat load variations equal to the maximum rates of change defined in 3.2.4.3.2.

3.2.2.5.4 OA Interface Long-Term Temperature Stability

The Dewar shall be capable of limiting the variation of the OA cold-button interface temperature to no greater than ±250 mK (TBR) over a 24-hour period, given the Dewar thermal interface temperature variations and heat load variations equal to the maximum rates of change defined in 3.2.4.3.2.

3.2.2.6 FPM Annealing

The Dewar shall support the needs of the FPM detector to perform a warm up to 20K for 1 minute (to anneal defects caused by Cosmic Ray impacts).

3.2.2.6.1 FPM Annealing Heat Load

The heat load as a function of time from each annealing procedure shall be documented by JPL in the Dewar-MIRI ICD. Each detector annealing procedure will result in a peak heat load to the Dewar of 0.3Watts (for less than 1 minute) (TBR).

3.2.2.6.2 FPM Annealing Energy

For Dewar life calculations, the detector annealing procedure shall be assumed to sink 75 Joules (TBR) to the Dewar.

3.2.2.6.3 FPM Annealing Frequency

For Dewar life calculations, the detector annealing procedure shall be assumed to take place 180 (TBR) times (once per month per FPM) during the mission.

3.2.2.6.4 FPM Annealing Recovery

Following this detector annealing procedure, the Dewar TSIs shall return to their nominal temperatures and stabilities within 2 (TBR) hours.

3.2.2.7 Lifetime

3.2.2.7.1 Operating Life, non-consumables

The Dewar Assembly shall have an operating life for all non-consumables of no less than 6 years in-space operation and 3 years post delivery ground-test operation.

3.2.2.7.2 Operating Life, Consumables

All consumables in the Dewar Assembly, such as stored cryogens, shall be sized to provide an operational lifetime after the Dewar and the OBA have reached their Baseline Operating Point as defined above that is greater than five (5) years and two (2) months. The consumables shall be sized to accommodate all losses associated with launch operations, the cool-down of the host (ISIM) environment (see below), and the cool-down of the OBA (including the final cool down from 70K to the Operating Point).

3.2.2.7.2.1 *Lifetime predictions*

Lifetime predictions shall take into account the required ground hold autonomy period at the launch site, the launch phase, the ISIM cooldown phase, the MIRI OBA cooldown phase, and the Operational phase (5 years 2 months).

3.2.2.7.2.2 *Remaining Operating life- Cryogen Mass Measurement*

The quantity of cryogen remaining in the tank(s) shall be known with an accuracy better than 5% (TBR) under all ground and on-orbit operations.

3.2.2.7.3 Storage Life

The MIRI Dewar shall be capable of meeting its specified performance requirements after being stored without cryogen (i.e., warm) for up to 2 years (TBR) with minimal rework or reconditioning.

3.2.2.7.4 Cooling Cycles

The Dewar shall be designed to operate for no less than 25 (TBR) cryogenic cooling cycles over its operating life.

Note: A cryogenic cooling cycle consists of a cooldown from ambient to cryogenic temperatures of the interior and then exterior of the Dewar and then a warm-up from cryogenic to ambient temperatures.

3.2.2.7.4.1 Thermal Cycles Before Delivery

The Dewar shall be capable of withstanding 10 (TBR) cryogenic thermal cycles as defined above prior to delivery.

3.2.2.7.4.2 *Thermal Cycles After Delivery*

The Dewar shall be capable of withstanding 15 (TBR) cryogenic thermal cycles as defined above after delivery (in test and on orbit) and N (TBR) cycles of its exterior interfaces from 50K to 30K.

3.2.2.7.5 Predicted End of Life (EOL) Condition.

The Predicted EOL Condition of the Dewar is defined as the predicted physical status of the Dewar after it has been exposed to ALL of the following environments:

1. Run at the Baseline Operating Point for the operating life defined by 3.2.2.5.1
2. Stored for the Storage Life defined by 3.2.2.5.2
3. Subjected to the Cooling Cycles defined by 3.2.2.5.3
4. Subjected to three complete vibration test campaigns as defined in 4.4.5
5. Subjected to three complete thermal/vacuum test campaigns as defined in 4.4.2

6. Suffered the maximum leakage as defined in 3.3.3.7
7. Subjected to the thermal-cycle environment defined in 3.3.3.8

3.2.2.7.6 Dewar Component Mechanism Life

Life testing is required on all mechanisms (heat switches, valves, etc.). Life shall be demonstrated using the factored sum of the predicted nominal ground test cycles and the in-flight operation cycles. For test demonstration, the number of predicted cycles shall be multiplied by the factors specified in the table below.

Type	Number of Predicted Cycles	Factor
Ground Testing	Number of On-Ground Test Cycles (Minimum 10)	4
Flight	1 to 10 Cycles	10
	11 to 1,000 Cycles	4
	1001 to 1000,000 Cycles	2
	> Than 1000,000 Cycles	1.25

3.2.3 Interfaces

3.2.3.1 Structural Mounting Interfaces

3.2.3.1.1 Dewar Subsystem

The Dewar subsystem assembly shall be mounted to the ISIM structure using a set of four Kinematic Mounts (KM) from the four mounting points shown in Figure 3.2.1.1.2-1.

3.2.3.1.1.1 Interface Loads for Kinematic Mounts

The interface loads at the base of each KM during cooldown from 293K to 30K shall fall in the acceptable region of Figure 3.2.3.1.1.1-1 given the thermal expansion properties of the ISIM mounting location as given in 3.2.3.1.1.2.

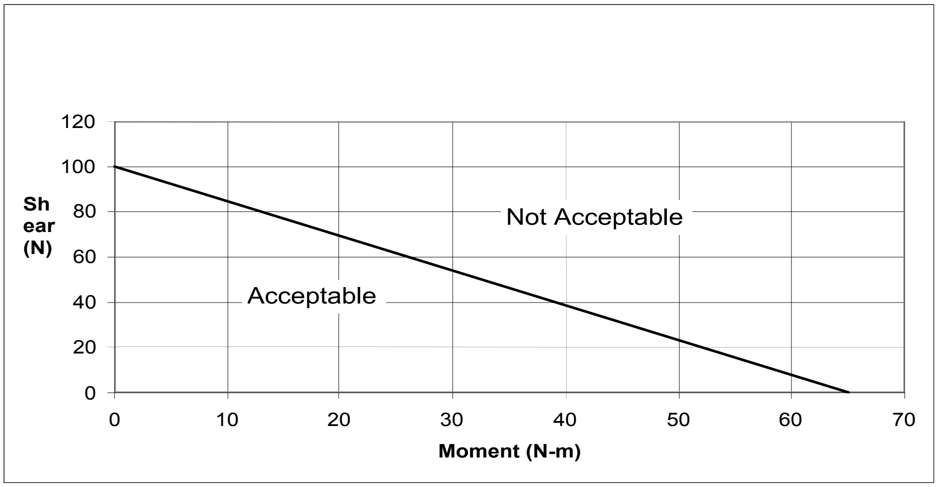


Figure 3.2.1.1.1-1: Shear and Moment Allowables at Base of KMs for Cooldown

3.2.3.1.1.2 Differential Thermal Expansion

The MIRI Dewar footprint mounting points on the ISIM shall be assumed rigid with a combined thermal, moisture release and gravity release strain of +250 micro-strain expansion in the interface mounting plane upon cooldown.

3.2.3.1.1.3 Mounting Loads Thermal Expansion

During operation, the maximum change in moment and shear loads introduced into the ISIM bench by temperature fluctuations in MIRI shall be less than 3% (TBR) of the maximum levels introduced by the cooldown process

3.2.3.1.1.4 Launch Configuration

The MIRI Dewar will be launched in the +V3 up orientation.

3.2.3.1.1.5 Lifting Points and Transportation Interfaces

The lifting points and transportation interfaces shall be arranged such that (except for the lifting points themselves) ground-handling loads will not constitute a critical load case.

3.2.3.1.2 Thermal Strap Interfaces

The Thermal Strap Interface(s) shall have mounting provisions that allow them to efficiently support the attached thermal straps. Up to 2 kg (TBR) of thermal strap mass may be supported off either TSI.

3.2.3.1.2.1 Thermal Strap Mechanical Interface

The FPM and OA TSIs shall be configured with bolted-joint conductive cryogenic load interfaces suitable for conducting the cryogenic loads to the Dewar with a thermal resistance of < 0.5 K/W (TBR) across the bolted joint and partially structurally supporting the heat straps from the TSIs.

3.2.3.1.2.2 Thermal Strap Interface Location

The Dewar TSI mounting points shall be located within the envelope whose corners are as given in the table below (ISIM coordinate system). The exact interface points and their design shall be documented in the Dewar-MIRI ICD.

Note: The two points define corners of a rectangular parallelepiped with surfaces parallel to the V1, V2, and V3 coordinate system. See Figure 3.2.3.1-1 below for cartoon of the location of this interface within the ISIM.

Point	V1	V2	V3
A	-1510 mm	-600 mm	+730 mm
B	-1310 mm	-400 mm	+885 mm

3.2.3.1.2.3 Thermal Strap Interface Flatness

The Thermal Strap Interfaces shall be flat to <0.1 mm to assure a good thermal joint with the cold load interfaces. The surface shall not lose its flatness after 50 repeated attachment-detachment cycles using representative joint preparation processes.

3.2.3.1.2.4 Thermal Strap Electrical Isolation

The mounting surface of the MIRI Optical Bench Assembly thermal straps shall be electrically connected to the mounting interface of the Dewar (TBR). Any electrical isolation required by the Dewar shall be the responsibility of the Dewar supplier. The degree of electrical connection between the thermal straps and the TSIs shall be less than 10mOhm.

3.2.3.1.2.5 *Thermal Strap Grounding*

The Dewar Chassis ground connection shall be via the ISIM and not via the OBA thermal straps.

3.2.3.1.3 Piping Assembly

The Dewar subsystem external piping assembly shall be routed through the ISIM enclosure. The flight vents shall be routed out the V3 (top) side of the enclosure, while all servicing (vent/fill) and emergency vent lines shall be routed to the –V2 side of the enclosure. Piping locations shall be negotiated with JPL and documented in the Dewar-MIRI ICD. Preliminary

Preliminary locations (TBR) for the interfaces through the ISIM enclosure for use in responding to the RFP **ONLY** are shown in Figure 3.2.3.1.3-1, and are given in the table below (opposite corners of the rectangle defining the allowable location of the interface are given). The flight vent(s) should extend beyond the enclosure at least 750mm, ending in a thrust nullifier. All servicing line connections must be made within the Dewar envelope (i.e. nothing sticks beyond the ISIM enclosure after all the servicing lines have been removed).

Type	Dim of box	V1	V2	V3
Servicing/emergency vent	300 X 300 mm	-1725 mm -1425 mm	-1190 mm -1190 mm	+900 mm +1200 mm
Flight vent 1	300 X 300 mm	-1375 mm -1671 mm	-390 mm -108 mm	+2298 mm +2195 mm
Flight vent 2 (if needed)	300 X 300 mm	-1424 mm -1587 mm	+108 mm + 390 mm	2375 mm 2103 mm

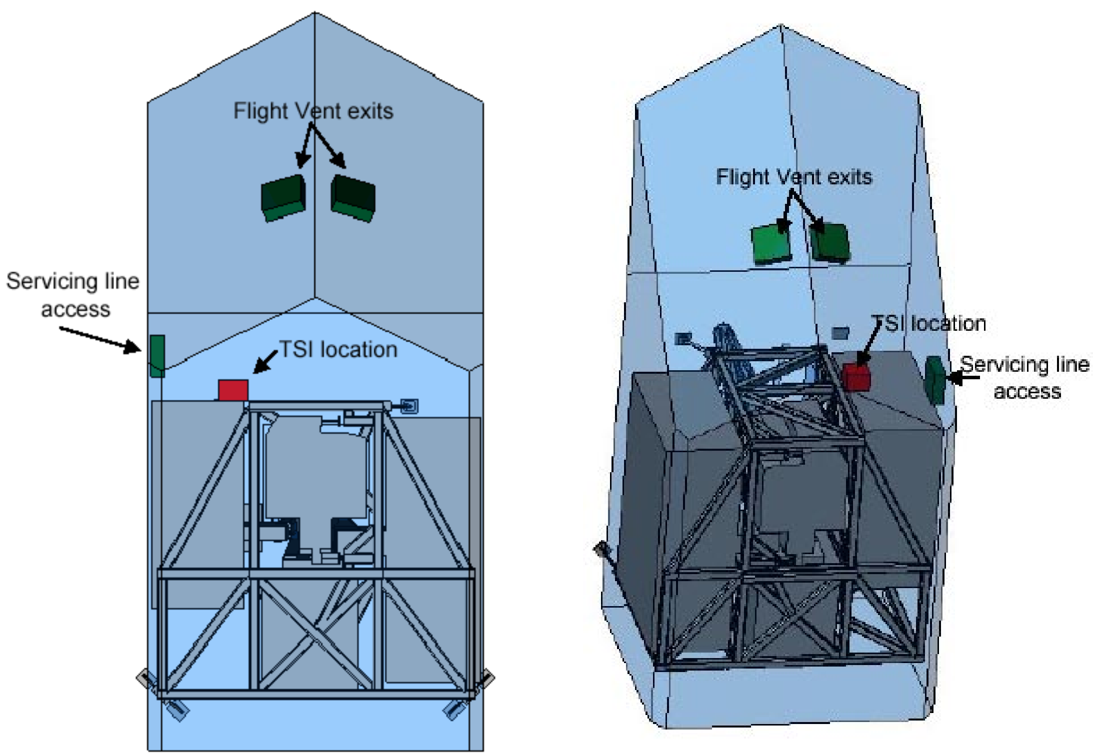


Figure 3.2.3.1.3-1 Physical interface locations for the TSI(s) and the Piping assembly

3.2.3.1.4 Dewar Control Electronics Assembly

The Dewar Control Electronics assembly shall be designed to be mechanically supported from the host S/C in a manner that is consistent with efficient structural support and removal of the heat dissipated by the electronics per 3.2.3.2.7. As a goal, the thermal interface shall be a flat rectangular conductive surface with an area less than 0.05 m^2, with provisions for being bolted to a flat mounting plate.

3.2.3.1.4.1 DCE Mounting Location

The DCE mounting point location shall be as delineated in the Dewar-MIRI ICD

3.2.3.1.4.2 DCE Mounting Method

The DCE locations and dimensions of the holes for mounting hardware shall be documented in the Dewar-MIRI ICD.

3.2.3.1.5 Mounting Hole Tolerancing

Mounting hole tolerancing shall be determined by the contractor (TBR) in accordance with ASME Y14.5M, "Dimensioning and Tolerancing", or equivalent.

3.2.3.1.6 Flight Mounting Hardware

Mounting hardware shall be defined in the Dewar-MIRI ICD.

3.2.3.1.7 Flight Mounting Surface Flatness

Finish and flatness requirements for the mounting surfaces shall be documented in Dewar-MIRI.

3.2.3.2 Thermal Interfaces

3.2.3.2.1 Harness Parasitic Heat Loads and Internal Dissipation

The maximum parasitic heat load on to the ISIM from the Dewar-DCE harness shall be less than 3.25mW (TBR).

Note: Maximum parasitic heat load requirements shall be calculated assuming a 6-meter section over which a temperature drop occurs, with the warm end at 300K, and the cold end at the ISIM at 35K.

Note: For the harness parasitic and dissipation loads, the following definitions and calculation methods will be used. Parasitic heat is defined as the total of heat conducted from the warm side to the cold side plus Joule heating (i.e. ohmic loss when current is flowing) in the harness that is conducted to the cold side. Radiation heat transfer will not be included in this calculation.

3.2.3.2.2 Harness Parasitic Heat Loads and Internal Dissipation – Maximum Local Instantaneous Peak Temperatures

Maximum local instantaneous peak harness wire or insulation temperature shall never exceed 350 K (**TBR**) when both ends are maintained at 300 K during any ground or flight use. This requirement shall be verified by short-term (24 hour) test and long-term (to steady-state) analysis by the contractor.

3.2.3.2.3 TSI Temperature, Steady State Operations

The temperature of the FPM TSI shall be less than 6.65K during steady state operations, and the temperature of the OA TSI shall be less than 7.6K during steady state operations. These temperature requirements shall be met with the heat loads on the TSI at their maximum loads.

3.2.3.2.3.1 *TSI Heat Loads, Steady State Operations*

The heat loads the Dewar must heat sink coming from the FPM and OA thermal straps into the TSIs shall be: FPM-TSI =4.7mW, OA-TSI=55.3mW. The maximum steady state heat loads shall be the nominal values stated plus the maximum variation of the heat loads as given in 3.2.4.3.2.

3.2.3.2.4 Cold Load Transient Thermal Properties

The following thermal properties shall be used for computing Dewar transient thermal performance:

3.2.3.2.4.1 FPM Thermal Mass

The total energy to be sunk to the Dewar from the FPM strap during cooldown from heat switch closure to cold stability is 9.9 kJ (TBR). (Note: this assumes a 70K heat switch activation temperature).

3.2.3.2.4.2 OA Thermal Mass

The total energy to be sunk to the Dewar from the OA strap during cooldown from heat switch closure to cold stability is 976 kJ (TBR). (Note: this assumes a 70K heat switch activation temperature.)

3.2.3.2.4.3 Post launch cooldown

After launch through the heat switch activation, the TSIs and the other thermal interfaces (the ISIM conductive and radiative) temperatures will be as shown in Figure 3.2.3.2.4.3-1. The temperature profile of the TSIs prior to heat switch activation depends on the open heat switch conductance. Two bracketing cases (K=0.1mW.K and K=0.4mW/K) are shown.

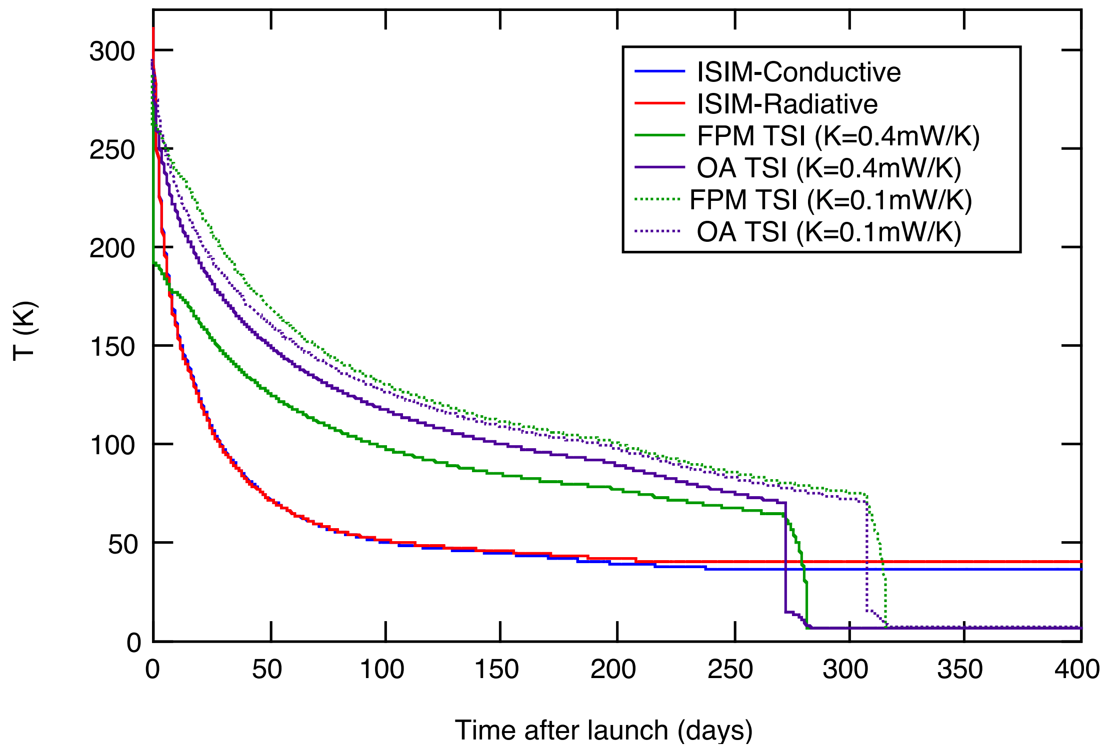


Figure 3.2.3.2.4.3-1: Slowest expected cooldown profile of the ISIM and OBA side of the TSIs.

The TSI for the FPMs will follow the green curve, for the OA the purple curve. The ISIM conductive interface (mounts and piping) will follow the blue curve, and the ISIM radiation environment will follow the red. The dotted green and purple curves are for a smaller heat switch open resistance than the solid green and purple curves (0.1mW/K versus 0.4mW/K).

3.2.3.2.5 Dewar External Surface Temperature

The Dewar external surfaces inside the ISIM enclosure shall be less than 40 K during normal operations.

3.2.3.2.6 DCE Temperature Range

The DCE shall be held within the temperature range of 273K to 313K for normal operations.

3.2.3.2.7 DCE Non-Operating Temperature Range

The DCE shall be capable of surviving a temperature range of 253K to 323K for an indefinite time period while in Off Mode without permanent degradation of performance.

3.2.3.2.8 DCE Location

The DCE shall be located in Region 2 of the ISIM (warm region on the exterior of the ISIM enclosure).

3.2.3.2.9 DCE Thermal Properties

The electrical box provider shall responsible for provision of surface finishes, MLI, and conductive paths and the documentation of these in the Dewar-MIRI ICD.

3.2.3.2.10 Electronics Heat Rejection Interface

The Dewar control electronics shall be designed to reject all of its heat conductively through the baseplate to the SC-controlled mounting surface.

3.2.3.2.11 Region 2 Temperature Monitoring of the DCE

The contractor shall design the DCE to accommodate temperature sensors required to monitor 'critical' DCE temperatures during operations.

Note: The SC will monitor 'critical' MIRI temperatures as delineated by the Dewar-MIRI ICD. Internal and/or external temperature monitoring devices for the DCE, if identified as 'critical', will be provided by JPL.

3.2.3.2.12 Region 2 – DCE Heaters

The location and temperature monitoring characteristics of all MIRI temperature sensors shall be documented in the Dewar -MIRI ICD and provided to JPL.

3.2.3.2.13 DCE – Temperature Stability Control

The contractor shall provide all items necessary for precision temperature stability control of the DCE when powered and may include blankets, heaters (survival, and any required during operations), thermometers, and except for survival, the DCE shall provide all thermal control needed to meet its performance specification.

3.2.3.2.14 DCE – Thermal Control Hardware Documentation

The contractor shall document the use of all thermal control hardware in the Dewar-MIRI ICD and provided to JPL.

3.2.3.3 Electrical Interfaces

3.2.3.3.1 Power Interface

The DCE shall receive primary power from the SC EPU.

3.2.3.3.1.1 Primary Power Switching and Controll

The SC will provide the switching and control of all DCE prime and redundant power feeds (**TBR**).

3.2.3.3.1.2 DCE Power On

The DCE shall be powered on at launch to receive launch critical commands from the SC CTP to open the Dewar valve.

3.2.3.3.1.3 MIRI Power Allocation

Primary power consumed by Dewar electrical equipment shall be less than or equal to the power listed in Table 3.2.3.3.1.3-1 for the DCE.

Table 3.2.3.3.1.3-1. MIRI Region 2 Power Allocations

SC Mode *Item*	**Launch Power (Watts)**	**Operational Power (Watts)**			*Survival Power (Watts)*
		Average (30-day)	*Average (1-hour)*	**Absolute Peak**	
MIRI DCE	6 (TBR)	6 (TBR)	**TBD**	**TBD**	**TBR**

Note: One-hour average power allocation is based on the MIRI acting as the prime observing instrument.

3.2.3.3.1.4 Input Voltage

The Dewar subsystem shall meet the performance requirements of this specification when supplied with power at a nominal input voltage of +28 V dc with an allowable range of 22 V dc to 35 V dc. This is the full range of voltage at the MIRI power input connector including ripple voltage on the input power bus. Note: The nominal voltage supplied by the Spacecraft to the ISIM equipment will be 30 to 32 Vdc (**TBR**) in the Observatory pointing mode. This nominal voltage is not a requirement but information for design optimization purposes. Above voltages assumes no solar array cell losses.

3.2.3.3.1.5 Undervoltage Tolerance

All MIRI components shall withstand, without damage and/or autonomous response potentially damaging to other equipment, any under-voltage below 22V down to zero for an indefinite period of time.

3.2.3.3.1.6 Unannounced Removal of Voltage

All MIRI components shall be designed to withstand unannounced removal of primary power without any permanent damage or degradation.

3.2.3.3.1.7 Fuse Blow Transients

All MIRI components shall withstand a single event fuse blow transient where the primary power bus drops to as low as 5 Vdc (for 600 microseconds) and reaches a high of 65 Vdc (for

100 microseconds) without damage and without propagating damage to other equipment, e.g. from back Electromagnetic Force (EMFs) from motors, coils, etc.

3.2.3.3.1.8 Abnormal Steady-State Over-Voltage Tolerance

All MIRI components (DCE) shall withstand an abnormal steady state power over-voltage of up to 40V (**TBR**) for an indefinite period of time.

3.2.3.3.1.9 Spacecraft Voltage Ripple

The SC power source voltage ripple will be +/- 500 mV peak-to-peak.

3.2.3.3.1.10 MIRI Voltage Ripple

The total ripple on the primary power system generated by MIRI about any quasi-static service voltage, including repetitive spikes, measured at the spacecraft to MIRI interface shall not exceed +/-200 mV (**TBR**) peak-to-peak measured in the time domain and using the SC power source impedance specified in 3.2.3.3.1.11

3.2.3.3.1.11 SC Power Source Impedance

Note: The SC design will be such that the power bus impedance at the interface between the instrument and the SC harness, looking back at the SC source, will be less than as shown in Figure 3.2.3.3.1.11-1.

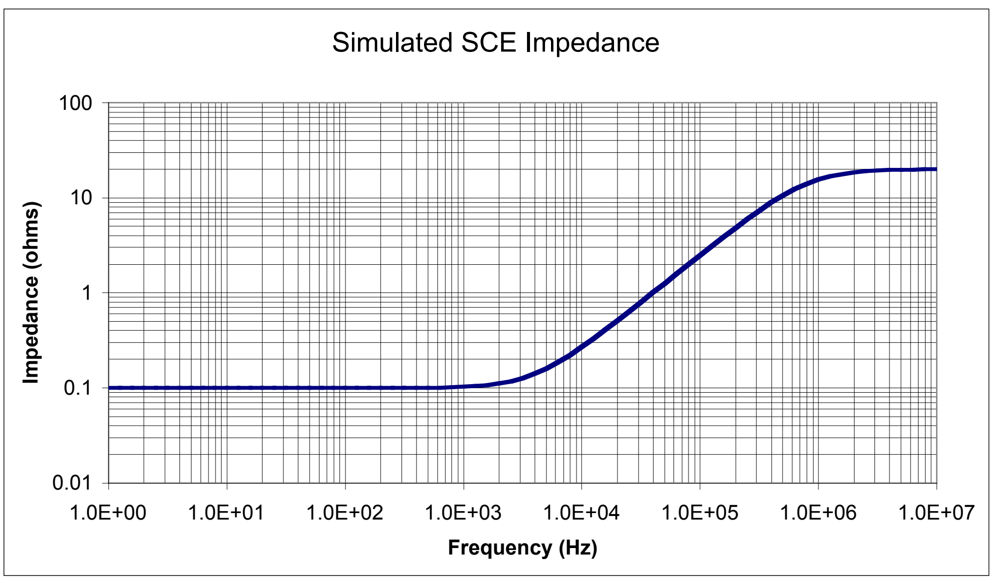


Figure 3.2.3.3.1.11-1. Power Bus Impedance at Spacecraft-MIRI Interface (TBR)

3.2.3.3.1.12 MIRI Turn-On/Non-Repetitive Current Transient Amplitude

For all MIRI components, the in-rush current transient and non-repetitive operational current transient shall not exceed 10 times (1000%) the operational peak current during the first 10μseconds from the start of the transient, 2 times (200%) the operational peak current between 10 μs and 50 ms from the start of the transient, and return to steady state within 50 milliseconds (ms) of the time of the transient peak.

3.2.3.3.1.13 *MIRI Transient Rate of Change During Normal Operation*

For each MIRI component, the maximum current rate of change during normal operation shall be less than 20 milli-Amps (mA)/ μs.

3.2.3.3.1.14 *MIRI Transient Rate of Change During Turn-On*

For each MIRI component, the maximum rate of change during turn-on/turn-off transients shall be less than 50 mA/μs.

3.2.3.3.1.15 *MIRI Turn-Off Voltage Transients*

The peak turn-off transient voltage caused by inductive effects of the MIRI electrical equipment shall stay within the range of -2V to +40V.

3.2.3.3.1.16 *Overcurrent Protection*

Fuses shall not be used in any MIRI component on its connections to primary power.

Note: The size of the overcurrent protection devices for each ISIM power connection will be per agreement between the SC and ISIM providers, and will be sized based on JWST and PPL Guidelines.

3.2.3.3.2 Command and Data Interface ISIM

The Dewar shall implement a MIL-STD-1553B serial bus telecommunications (Verify) link with the command and data handling subsystem of the ISIM (IC&DH). The ISIM MIL-STD-1553B Bus Topology is shown in Figure 3.2.3.3.2-1.

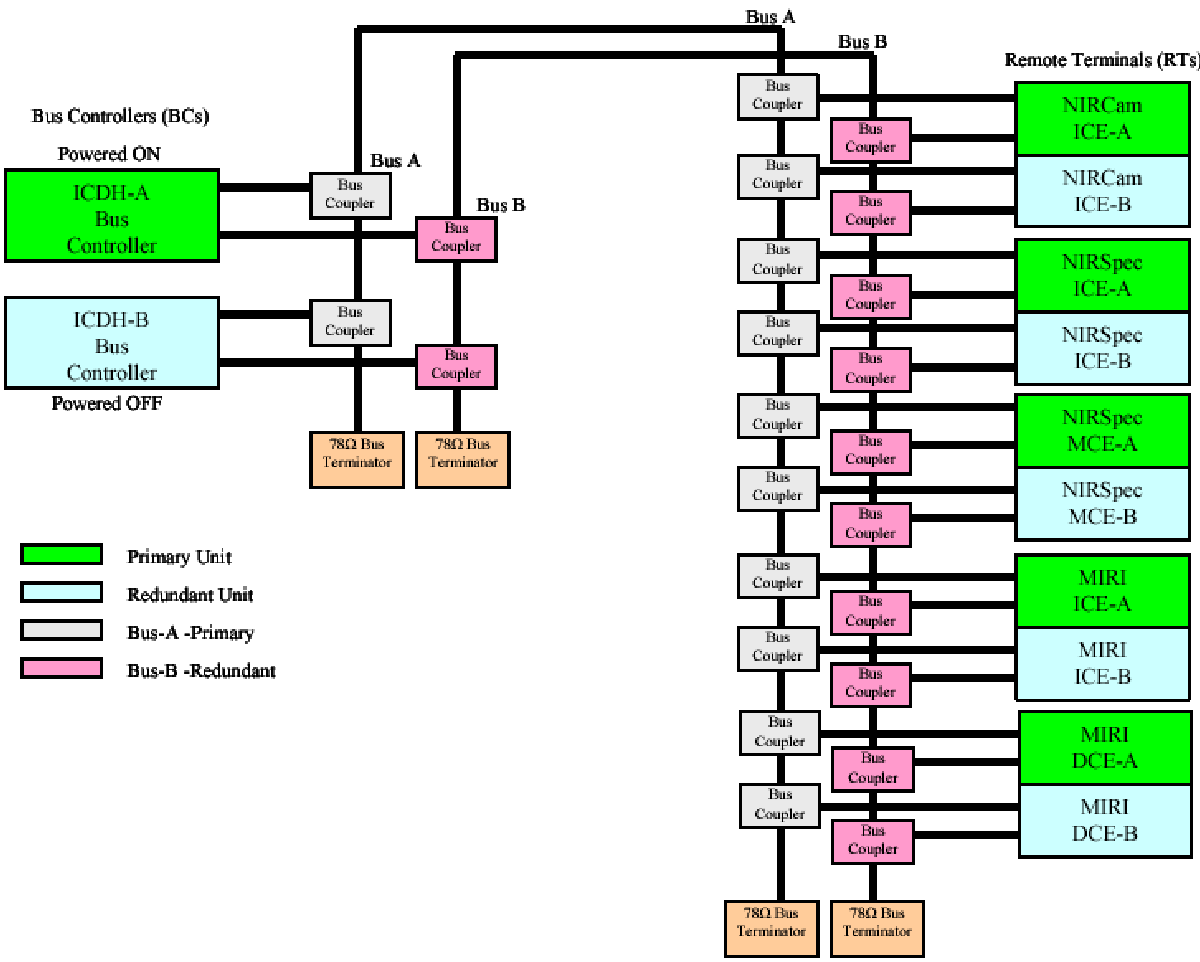


Figure 3.2.3.3.2-1. ISIM MIL-STD-1553B Bus Topology

3.2.3.3.2.1 *MIL-STD-1553B Bus – General Requirements*

The DCE and the ICDH shall communicate with each other over the ISIM MIL-STD-1553B bus.

3.2.3.3.2.2 *MIL-STD-1553B Bus – Remote Terminals*

The DCE shall be a Remote Terminal (RT).

3.2.3.3.2.3 MIL-STD-1553B Bus – Redundant RT

Each MIRI DCE component (prime and redundant) shall provide a RT connection.

3.2.3.3.3 Command and Data Interface SC

The Dewar shall implement a RS 422 serial bus telecommunications link with the command and telemetry processor of the host S/C (CTP).

3.2.3.3.3.1 RS 422 Bus – General Requirements

The DCE and the SC CTP shall communicate with each other over the 422 bus.

3.2.3.3.3.2 RS 422 – Redundant

Each MIRI DCE component (prime and redundant) shall provide a redundant connection.

3.2.3.3.4 Passive/Analog Telemetry

3.2.3.3.4.1 Discrete Passive/Analog – ICDH

The Dewar contractor shall identify a number not to exceed TBD discrete passive analog telemetry points to be monitored by the IC&DH.

3.2.3.3.4.2 Discrete Passive/Analog – SC CTP

The Dewar contractor shall identify a number not to exceed TBD discrete passive analog telemetry points to be monitored by the SC CTP.

3.2.3.3.5 Discrete Active Analog Telemetry

3.2.3.3.5.1 Discrete Active Analog – ICDH

The Dewar contractor shall identify a number not to exceed TBD discrete active analog telemetry points to be monitored by the IC&DH.

3.2.3.3.5.2 Discrete Active Analog – SC CTP

The Dewar contractor shall identify a number not to exceed TBD discrete active analog telemetry points to be monitored by the SC CTP.

3.2.3.3.6 Discrete Bi-Level Telemetry

3.2.3.3.6.1 Discrete Bi-Level – ICDH

The Dewar contractor shall identify a number not to exceed TBD discrete bi-level telemetry points to be monitored by the ICDH.

3.2.3.3.6.2 Discrete Bi-Level – SC CTP

The Dewar contractor shall identify a number not to exceed TBD discrete bi-level telemetry points to be monitored by the SC CTP.

3.2.3.3.7 Discrete Commands

3.2.3.3.7.1 Discrete Commands – ICDH

The Dewar contractor shall identify not to exceed TBD discrete commands to be issued by the ICDH.

3.2.3.3.7.2 Discrete Commands – SC CTP

The Dewar contractor shall identify not to exceed TBD discrete commands to be issued by the SC CTP.

3.2.3.3.8 Dewar Interface Telemetry

3.2.3.3.8.1 Resistance and Heater Dissipation

The DCE shall be able to make and report resistance and heater dissipation measurements as often as every 10 seconds.

3.2.3.3.8.2 Variable Telemetry Rate

The DCE shall have a variable telemetry rate command able by either the spacecraft CTP or the ISIM IC&DH.

3.2.3.3.9 ICDH Configuration Commands to DCE

The ICDH shall provide configuration commands to the DCE.

3.2.3.3.10 ICDH Telemetry from DCE

The ICDH shall receive and process engineering telemetry from the DCE.

3.2.3.3.11 ICDH Telemetry from MIRI

The ICDH shall monitor TBD discrete telemetry signals from MIRI.

3.2.3.3.12 ICDH Functional Redundancy

The ICDH shall be functionally redundant.

3.2.3.3.13 SC CTP

The SC CTP shall send launch critical commands to DCE (i.e. to open the Dewar valve) **TBD** after launch.

3.2.3.4 Software Interfaces

3.2.3.4.1 Maximal data rate.

The maximum data rate shall be less than 20 (TBR) Mbits per day.

3.2.3.4.2 Data Frames, Housekeeping

The Dewar shall identify a standard housekeeping data frame for each operating mode described in section 7 below.

3.2.3.4.3 Data Frames, Critical data

The Dewar shall identify a critical data frame for each operating mode described in section 7 below.

3.2.4 Environmental Requirements

The Dewar shall be designed and manufactured to meet the applicable system and module requirements after being subjected to all the environmental conditions existing during all periods from ground activities to the end of in-orbit operations.

3.2.4.1 Ground Operations and Handling Environment

Note: Ground operations and handling environmental requirements include those environments the Dewar will encounter during assembly, integration, and testing until launch, as well as those environments the Dewar will encounter during transportation and storage in shipping containers.

3.2.4.1.1 Ambient Air Temperature

The Dewar shall meet the performance requirements of this specification after prolonged exposure in air at temperatures ranging from 283K to 305K.

3.2.4.1.2 Ambient Pressure

The Dewar shall meet the performance requirements of this specification after prolonged exposure to ambient air pressures in the range of 34.451 kPA to 108.418 kPA (TBR).

3.2.4.1.3 Relative Humidity

The Dewar shall meet the performance requirements of this specification after prolonged exposure to air at relative humidities in the range of 30 to 60% (TBR) Note: When the MIRI is under NASA control, the relative humidity shall be held between 30% and 50% (TBR).

3.2.4.2 Launch Environment

Note: The launch environmental requirements include those environments the Dewar will encounter during on-pad and launch operations through S/C separation.

3.2.4.2.1 Launch Temperature Range

The Dewar shall meet the performance requirements of this specification after exposure to interface temperatures during launch equal to the Flight Allowable Non-operating temperature range specified in 3.2.4.3.1.

3.2.4.2.2 Launch Pressure Decay

The MIRI shall be designed to withstand a maximum atmospheric pressure decay rate of 1.0 kilopascal (kPa)/sec (TBR).

3.2.4.2.3 Random Vibration

The Dewar shall meet the performance requirements of this specification after exposure to the Protoflight random vibration environment levels defined in Table 3.2.4.2.3-1 applied in each of the three principal orthogonal axes, for a duration of one minute per axis.

Notes:

The test article will be mounted to a fixture that provides base-excited motion at the mounting interface, 3.2.3.1.

The test article shall be non-operational during testing and any 3.3.2.9 launch restraint devices will be engaged.

Table 3.2.4.2.3-1. Protoflight Random Vibration Test Environment

Frequency (Hz)	ASD Level (G^2/Hz)	
	Qualification	Acceptance
20	0.026	0.013
20-50	+6 dB/oct	+6 dB/oct
50-800	0.16	0.08
800-2000	-6 dB/oct	-6 dB/oct
2000	0.026	0.013
Overall	14.1 G_{rms}	10.0 G_{rms}

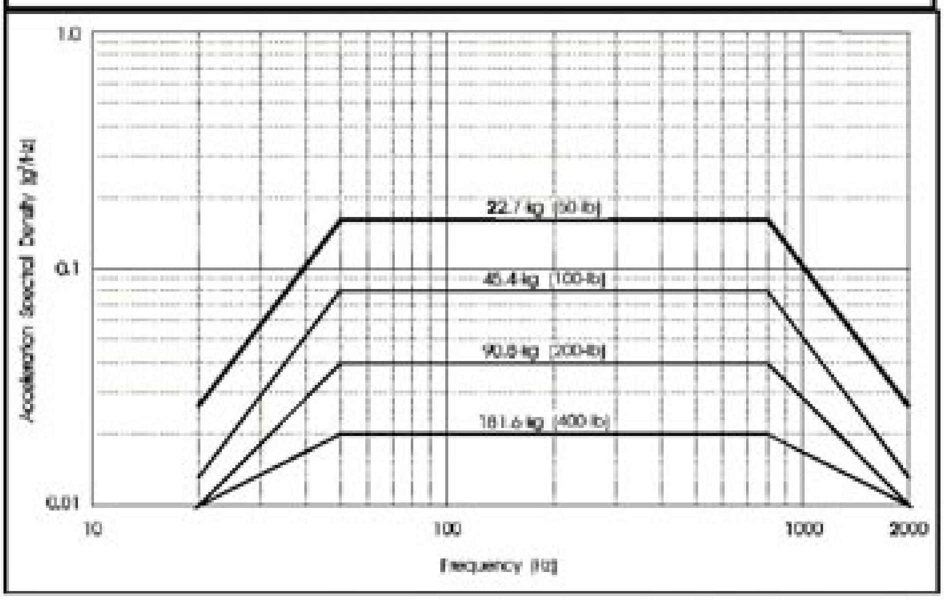
The acceleration spectral density level may be reduced for components weighing more than 22.7-kg (50 lb) according to:

	Weight in kg	Weight in lb	
dB reduction	= 10 log(W/22.7)	10 log(W/50)	
$ASD_{(50\text{-}800\ Hz)}$	= 0.16•(22.7/W)	0.16•(50/W)	for protoflight
$ASD_{(50\text{-}800\ Hz)}$	= 0.08•(22.7/W)	0.08•(50/W)	for acceptance

Where W = component weight.

The slopes shall be maintained at + and - 6dB/oct for components weighing up to 59-kg (130-lb). Above that weight, the slopes shall be adjusted to maintain an ASD level of 0.01 G^2/Hz at 20 and 2000 Hz.

For components weighing over 182-kg (400-lb), the test specification will be maintained at the level for 182-kg (400 pounds).



3.2.4.2.3.1 Random Vibration Minimum Workmanship

If a minimum workmanship test is necessary, as specified by the JWST Project, the random vibration levels defined in Table 3.2.4.2.3.1-1 shall be used.

Table 3.2.4.2.3.1-1. Protoflight Random Vibration Minimum Workmanship Test Environment

Frequency (Hz)	ASD Level (G^2/Hz)
20	0.01
20-80	+3 dB/oct
80-500	0.04
500-2000	-3 dB/oct
2000	0.01
Overall	6.8 G_{rms}

The plateau acceleration spectral density level (ASD) may be reduced for components weighing between 45.4 and 182 kg, or 100 and 400 pounds according to the component weight (W) up to a maximum of 6 dB as follows:

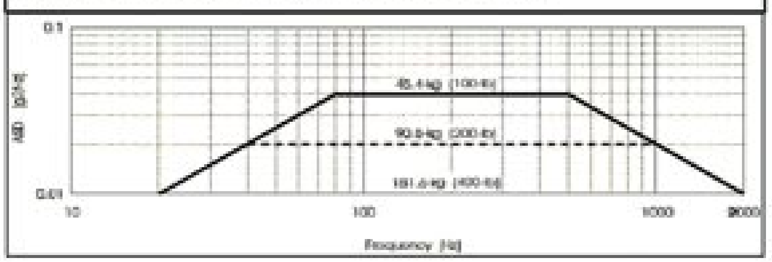
		Weight in kg	Weight in lb
dB reduction	=	10 log(W/45.4)	10 log(W/100)
$ASD_{(plateau)}$ level	=	0.04•(45.4/W)	0.04•(100/W)

The sloped portions of the spectrum shall be maintained at plus and minus 3 dB/oct. Therefore, the lower and upper break points, or frequencies at the ends of the plateau become:

F_L = 80 (45.4/W) [kg] F_L = frequency break point low end of plateau
= 80 (100/W) [lb]

F_H = 500 (W/45.4) [kg] F_H = frequency break point high end of plateau
= 500 (W/100) [lb]

The test spectrum shall not go below 0.01 G^2/Hz. For components whose weight is greater than 182-kg or 400 pounds, the workmanship test spectrum is 0.01 G^2/Hz from 20 to 2000 Hz with an overall level of 4.4 G_{rms}.



3.2.4.2.4 Sinusoidal Vibration

The Dewar shall meet the performance requirements of this specification after exposure to the sinusoidal vibration environment defined in Table 3.2.4.2.4-1 and Figure 3.2.4.2.4-1 below; applied in each of the three principal orthogonal axes, in one up-sweep from 5 Hz to 100 Hz (TBR) for each axis at 4 octaves/minute, however lower sweep rates may be included in TBD frequency bands to replicate the duration of flight events.

Notes:

1. The test article will be mounted in its launch configuration to a fixture that provides base-excited motion at the mounting interface, 3.2.3.1.
2. The test article will be non-operational during testing, and any 3.3.2.9 launch restraint devices will be engaged.
3. The protoflight sweep rate for 25 Hz to 35 Hz shall be 1.5 octaves/minute.

4. For frequencies where peak-to-peak stroke exceeds the shaker maximum stroke capability, the acceleration shall be limited to a fixed double amplitude.

5. Sinusoidal vibration testing is not required if the minimum resonant frequency of the component under test is greater than 150 Hz. .

6. Narrowband notching of these input levels will be allowed.

Table 3.2.4.2.4-1. Sinusoidal Protoflight Vibration Test Levels

Frequency	Amplitude/Acceleration
5 to 16.3 Hz	Displacement = 12 mm (double amplitude)
16.3 to 100 Hz	6.4 G_{peak}

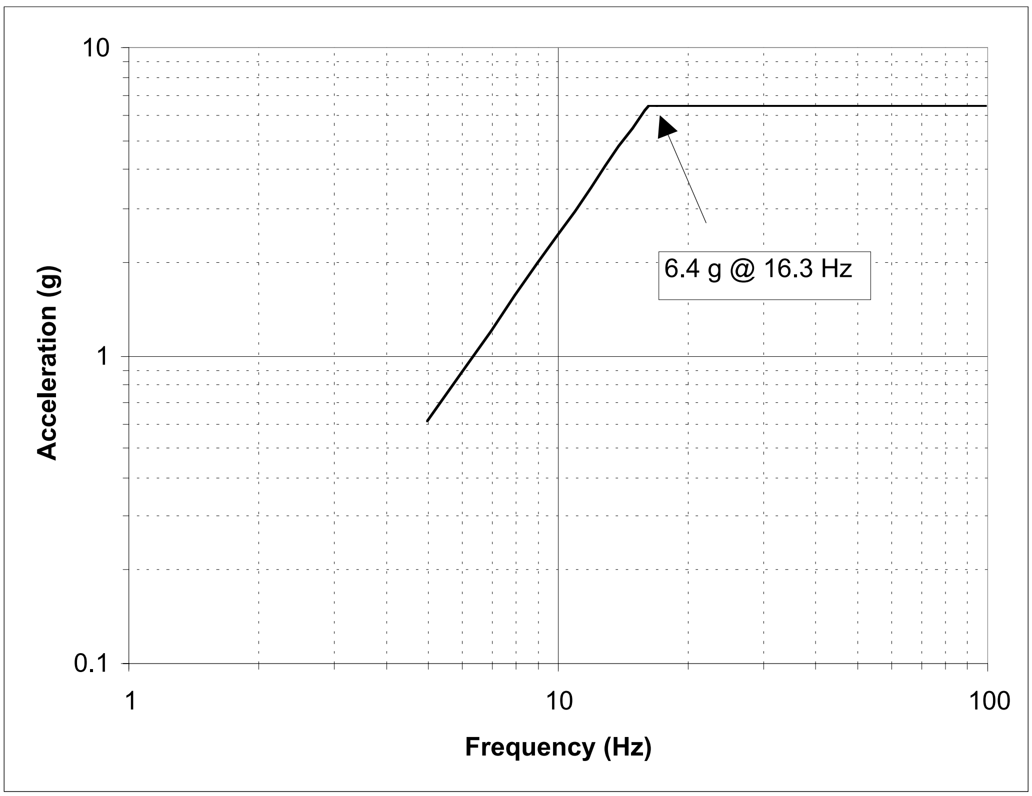


Figure 3.2.4.2.4-1. Sinusoidal Protoflight Test Levels (5 to 100 Hz)

3.2.4.2.5 Resonant Frequency Stability

The Dewar principal resonant frequencies shall not change more than 5 % following exposure to the random and sine vibration environments of 3.2.4.2.3 and 3.2.4.2.4.

Note: This determination shall be made by conducting a resonance search before and after Random and Sinusoidal testing in each axis using a 5 to 2000 Hz sinusoidal frequency sweep with a peak level of 0.25 g and a sweep rate of 2 oct/min. A >5 % frequency shift between before and after sweeps must be investigated as a possible structural failure.

3.2.4.3 Flight Structural/Thermal Environment

Comment: The flight Structural/Thermal environmental requirements include the thermal and mechanical environments the Dewar will encounter during in-space operation over its lifetime.

3.2.4.3.1 Thermal Interface Temperatures

Note: The Dewar must operate successfully over the broad range of S/C interface temperatures defined in Table 3.2.4.3-1.

3.2.4.3.1.1 Flight Allowable Temperature Levels

The Dewar shall meet the performance requirements of this specification during exposure to the "Flight Allowable-Operating" temperature range in Table 3.2.4.3.1.1-1.

Note: Baseline temperature is the expected operating environment for that component or interface. Since the Vent valve operates early in the mission, its baseline temperature is much warmer than its steady state temperature.

Note: Flight allowable temperatures are worst-case mission temperature extremes (including allowance for prediction uncertainties) that the hardware will experience in flight.

Note: Non-operating/Operating for the TSIs means the heat switches are open/closed.

Table 3.2.4.3.1.1-1. Thermal Interface Temperatures

Assembly	Base-line	Flight Allowable	
		Operating	Non-Operating
Dewar Vent Valve	290K	270K to 310K	22 K to 315K
ISIM conductive (mounts and piping)	37K	35 K to 37 K	22 K to 315K
ISIM Radiative Environment	40 K $\varepsilon < 0.7$	34 K to 40 K	30 K to 315K
DCE Heatsink	290K	270K to 310K	255K to 330K

3.2.4.3.2 <u>Thermal Interface Temperature Stability</u>

The Dewar shall be designed to meet the refrigeration performance requirements of 3.2.2, particularly the thermal stability requirements of 3.2.2.4, while its thermal interfaces fluctuate as noted in Table 3.2.4.3.2-1. The ISIM thermal environment is assumed to influence the Dewar thermal loads.

Table 3.2.4.3.2-1. Thermal Interface Stability During Dewar Operation

Assembly	Max. Rate of Change	Extremes per Day
DCE Heatsink	0.2 K/min	±3 K
FPM TSI Heat Load	0.5 mW/1000sec	1 mW
OA TSI Heat Load	5 mW/1000sec	10 mW
ISIM conductive interface	0.2 K/min	±3 K
ISIM radiative interface	TBD	TBD

3.2.4.3.2 Space Vacuum

The Dewar shall meet the performance requirements of this specification during exposure to vacuum levels from 10^{-6} torr to $2X10^{-10}$ torr.

3.2.4.3.3 Acceleration

The Dewar shall be designed to withstand a maximum acceleration of 0.015 g on orbit without permanent degradation of performance.

3.2.4.3.4 Acceleration/Shock

The MIRI shall be designed to meet performance requirements following exposure to the externally induced shock environment specified in Figure 3.2.4.3.4-1, as well as any self-induced shock.

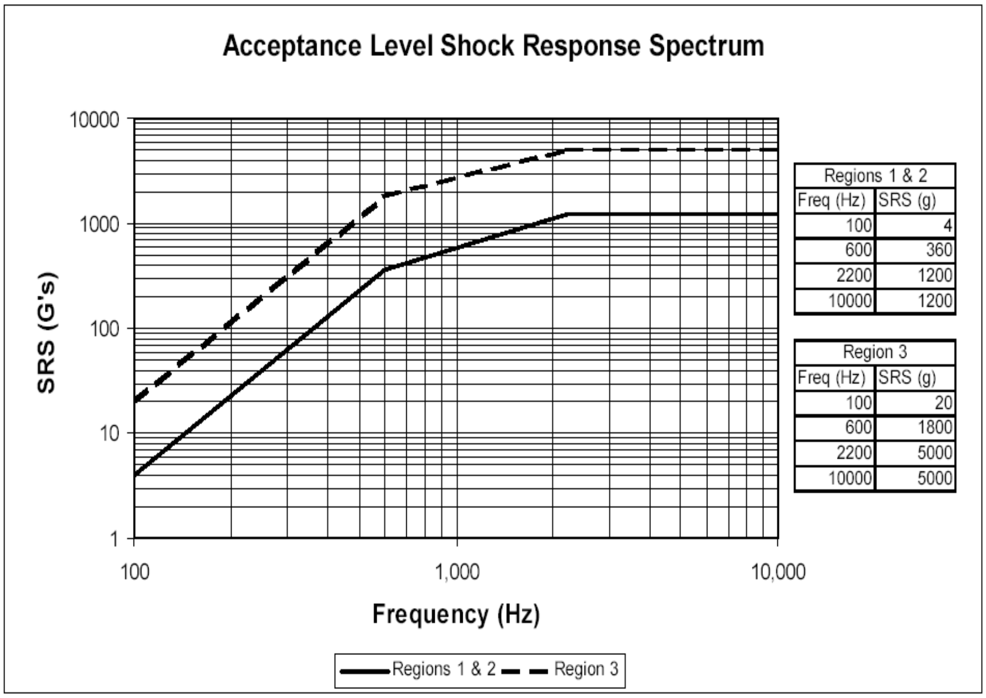


Figure 3.2.4.3.4-1. Flight Level Shock Spectrum

3.2.4.3.5 Externally-Induced Shock Testing

Testing of externally induced shock shall be conducted at the SC level. MIRI level testing is not required

3.2.4.3.6 Self-Induced Shock Testing

Testing for self induced shock shall be performed by operating any shock-inducing devices a minimum of two times.

3.2.4.4 Space Radiation Environments

3.2.4.4.1 Total Ionizing Dose

The Dewar and DCE shall meet the performance requirements of this specification following exposure to two times (i.e., radiation design margin, RDM=2) the expected 5-year total ionizing dose (TID) radiation environment.

Note: As top-level requirement, a level of 42.5 krads (Si) @2.54 mm of Al equivalent shielding is assumed for the 5 year mission (including the commissioning phase). Table A3 in the Appendix of JWST-RPT-000453 gives the TID as a function of shielding depth for the required 5 year mission and for the 5 year mission + the 5 year follow-on (which 7 years of proton flux during Solar Maximum).

Note: In calculating the TID requirements from Table A3, the 5-year mission doses are multiplied by 1.1 to account for the 6-month commissioning phase. No similar adjustment is necessary for the 10-year numbers, because the 7 years of solar maximum already represent a worst-case with respect to the solar cycle. Mission doses take into account the radiation dose incurred during transfer phase (TBD) from low-Earth orbit to L2 (estimated at about 2%-3% of the 5-year mission dose for a direct transfer to L2).

3.2.4.4.1.1 Displacement Damage Dose

The Dewar shall meet the performance requirements of this specification with no system-level degradation after exposure to a fluence of particles sufficient to cause two times the damage caused by the predicted mission environment.

Note: For materials (e.g. Si) where displacement damage may be parameterized in terms of the Nonionizing Energy Loss (NIEL), the mission damage fluence may be equated to an equivalent fluence of damaging particles for a given particle energy or energies (i.e. 1 MeV neutrons, etc.). For JWST, the radiation environment behind 2.54 mm Al equivalent shielding corresponds to an exposure to 2.94E11 50-MeV protons per cm2. The equivalent 10 year exposure (behind 2.54 mm Al equivalent shielding) is 3.42E11 50 Mev protons per cm2.

Note: These estimates were made using the proton fluences given in Table A2 of the Appendix of JWST-RPT-000453. As with the TID estimation, a 10% increase on the 5-year numbers is needed to account for the commissioning phase, and a roughly 2-3% contribution to account for the contribution during the transfer to L2 (for both the 5 year and year missions).

3.2.4.4.1.2 Displacement Damage Dose Without NIEL Correlation

In materials where displacement damage does not correlate with NIEL (or where the correlation is uncertain), the damage shall be calculated using the NIEL for the particle energy that maximizes the equivalent particle fluence.

Note: This will be determined by investigation of the energy dependence of the component degradation.

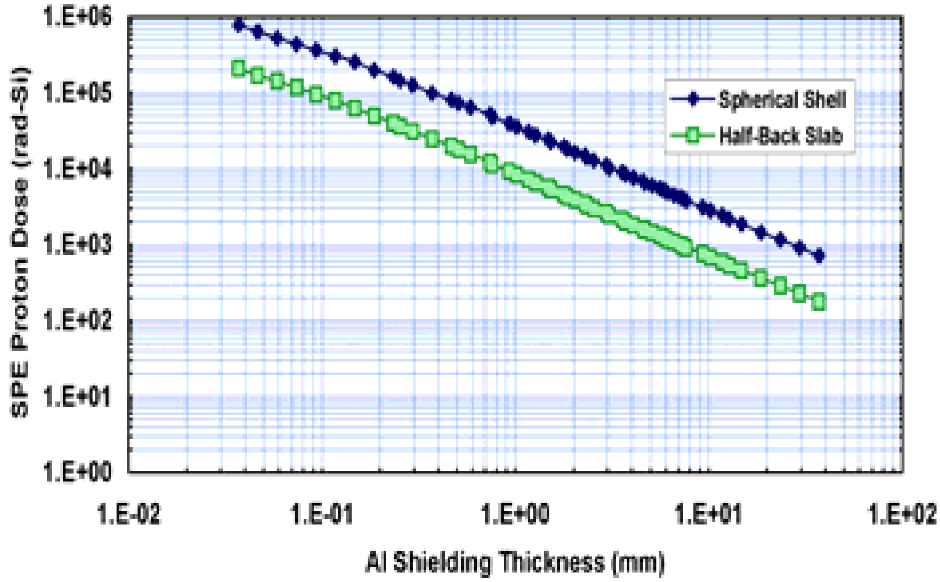


Figure 3.2.4.4.1.2-1. Total 5-year ionizing dose versus shielding thickness

3.2.4.4.2 Single-Event Effects

Single-Event Effects (SEE) in the Dewar Control Electronics shall not compromise the achievement of mission requirements.

Note: Heavy-ion SEE rates will be calculated using the heavy-ion environments in JWST-RPT-00453 (Appendix A4). Worst-case flare rates will be calculated using the worst flare rates in Appendix A5. Proton-induced rates will be calculated using the proton environment in Table A6 for flare conditions and Table A2 for quiescent solar conditions.

3.2.4.4.2.1 Destructive SEE

The Dewar Control Electronics shall only use parts that are not susceptible to destructive SEE.

3.2.4.4.2.2 Destructive SEE – MOSFETS

MOSFETs that are susceptible to single-event gate rupture (SEGR) and MOSFETs, FETs, bipolar transistors that are susceptible to single-event burnout (SEB) shall be operated with their application voltages in the safe operating region of the devices.

3.2.4.4.2.3 *Nondestructive SEE*

The allowable nondestructive SEE rates for the Dewar Control Electronics shall be as defined in Table 3.2.4.4.2.3-1.

Note: The rates and categories quoted in Table 3.2.4.4.2.3-1 are still **TBR**.

Table 3.2.4.4.2.3-1. Allowable Nondestructive SEE Rates* Dy^{-1} (All Values TBR)

	DT<1s	1s<DT<12 s	12 s <DT <1000s	1000 s < DT< 1dy	1 dy < DT < Permanent	Permanent
Loss of Telemetry	<20	<1	<0.1	<.005	<5E-4	<5E-4
Partial loss of Science Data	<2	<0.5	<6E-2	<6E-4	<1E-6	<1E-6
Loss of all Science Data	<2	<0.5	<6E-2	<6E-4	<1E-6	<1E-6
Partial Loss of Subsystem Functionality	<0.5	<0.01	<1E-3	<1E-3	1E-5	1E-5
Full Loss of Subsystem Functionality	<2E-3	<0.005	<6E-5	<6E-6	<1E-6	<1E-7
Partial Loss of Observatory Functionality	<2E-3	<0.0005	<6E-5	<6E-6	<1E-6	<1E-6
Places Observatory at Risk	<1E-3	<1E-4	<0.000001	< 1E-6	<1E-6	<1E-6
Full Loss of Observatory Functionality	<1E-2	<2E-3	<2E-4	< 2E-5	<1E-6	<1E-6

*These rates exclude ionizing events that occur in the SCA.

3.2.4.4.2.4 Nondestructive SEE – Aggregate Error Rates

The aggregate error rates for all susceptible parts in the instrument shall not exceed **TBD**.

3.2.4.4.3 Internal Charging

Dewar metallic elements, including wires, unused conductors of cable, connectors, circuit board traces, and spot shields, shall have a conductive path to ground of less than 10^8 Ω when measured in air and less than 10^{12} Ω when measured in vacuum.

Note: Since the internal charging environment is only moderate, components that are shielded from the external radiation environment by greater than 0.3 cm of aluminum (or equivalent) are not susceptible to internal charging and need not be grounded, except as provided for in 3.3.2.

3.2.4.5 Electromagnetic Interference

3.2.4.5.1 Conducted Emissions, Narrowband (CE01/03)

The Dewar's narrowband conducted emissions on power and power return leads shall be limited to the levels defined in Figure 3.2.4.5.1-1 when measured in accordance with the CE01 (30 Hz to 20 kHz) and CE03 (20 kHz to 50 MHz) test methods of MIL-STD-461C and MIL-STD-462, as appropriate. The measurement bandwidth shall be as defined in Table 3.2.4.5.1-1.

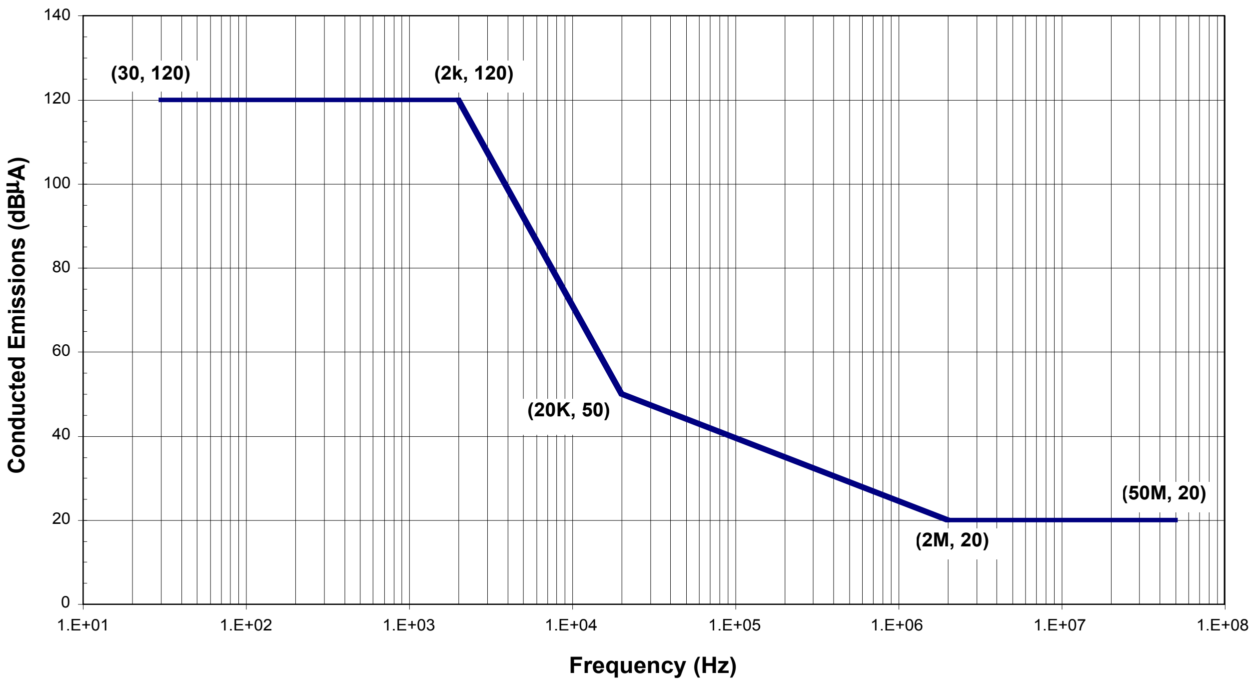


Figure 3.2.4.5.1-1. Allowable levels of narrowband conducted emissions

Table 3.2.4.5.1-1. CE01/CE03 Measurement Bandwidths (Narrowband)

Frequency Range	Bandwidth
30Hz – 3kHz	5Hz
3kHz – 2MHz	500Hz
2MHz – 30MHz	5kHz
30MHz – 50MHz	50kHz

3.2.4.5.1.1 Conducted Emissions, Narrowband Common Mode

The Dewar shall comply with the common mode conducted emissions limits shown in Figure 3.2.4.5.1.1-1. The common mode test procedure is the same as narrowband CE01/03 except the probe is placed around both the primary and return wires together. The measurement bandwidths shall be the same as in Table 3.2.4.5.1-1.

Conducted Emissions, Common Mode Time Domain: Common mode switching transient spikes between the component case and each of the following lines shall be less than 50 mV (**TBR**) peak: primary power, primary power returns, and signal ground.

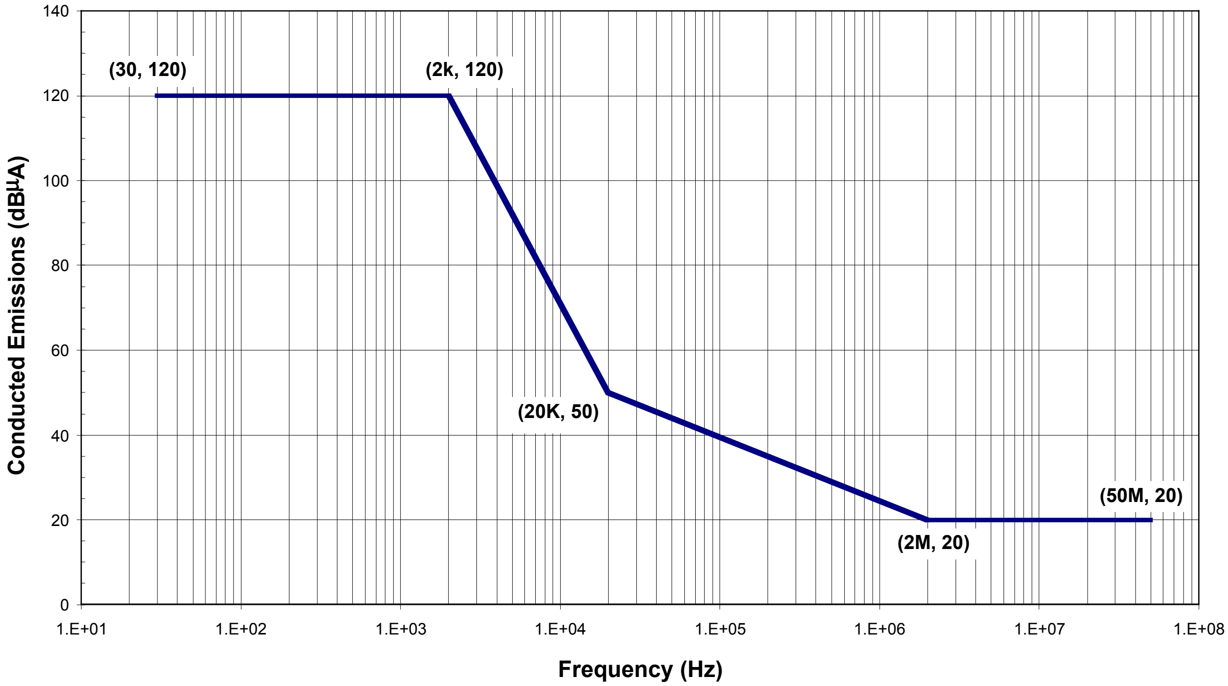


Figure 3.2.4.5.1.1-1. Common mode conducted emissions limits on primary power lines

3.2.4.5.1.2 Conducted Emissions, Broadband (CE03)

The Dewar's broadband conducted emissions on power and power return leads shall be limited to the levels defined in Figure 3.2.4.5.1.2-1. over the frequency range of 20 kHz to 50 MHz when measured in accordance with the CE03 test method of MIL-STD-462. The measurement bandwidth shall be as defined in Figure 3.2.4.5.1.2-1. Larger measurement bandwidths may be used; however, no bandwidth correction factors shall be applied to test data due to use of larger bandwidths.

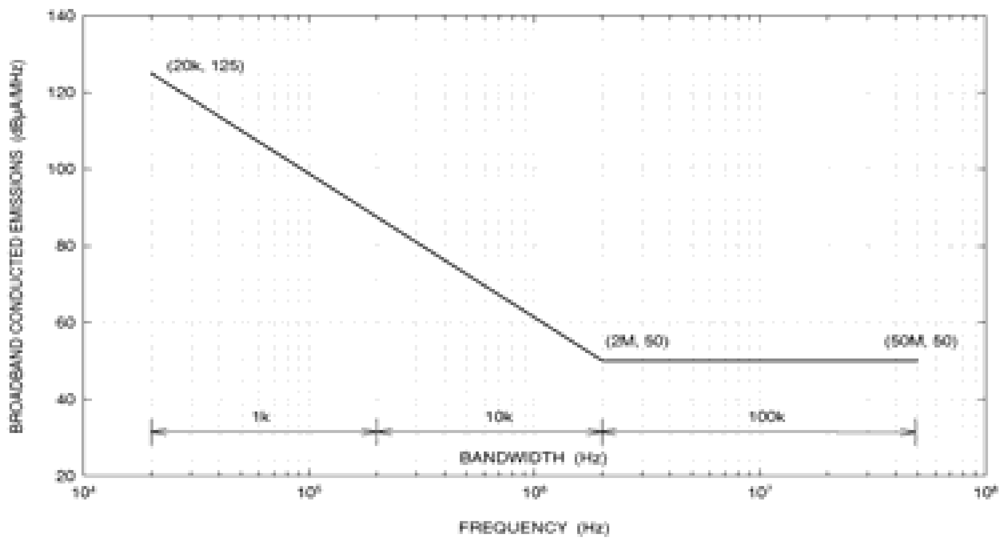


Figure 3.2.4.5.1.2-1. Allowable levels of broadband conducted emissions

3.2.4.5.2 Conducted Susceptibility, Power Leads (CS01/02)

The Dewar shall perform in accordance with the requirements of this specification during exposure to a sine wave superimposed on the bus voltage of each input power lead (primary power only) using the CS01 (30 Hz to 20 kHz) and CS02 (20 kHz to 400 MHz) test methods of MIL-STD-462. The amplitude of the superimposed sine wave is defined in Figure 3.2.4.5.2-1. The tests shall be performed for a bus voltage of 28 V dc.

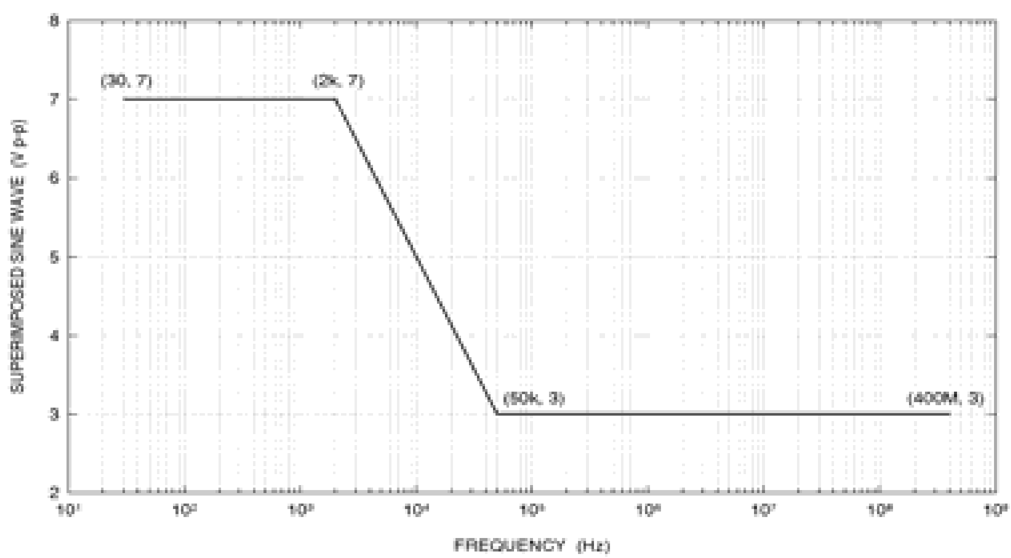


Figure 3.2.4.5.2-1. Definition of superimposed sine voltage for conducted susceptibility testing

3.2.4.5.3 Conducted Susceptibility, Power Leads Spike (CS06)

The Dewar shall perform in accordance with the requirements of this specification during exposure to positive and negative spikes applied to each input power lead (primary power only) using the CS06 test method of MIL-STD- 462. The spikes shall have a peak voltage equal to the steady-state power bus voltage (+/- 28V) and a pulse width (t_0) of 10 µs. The waveform of the spike is defined in Figure 3.2.4.5.3-1. The spikes shall be applied at a repetition rate of 60 pulses per second for a duration of 5 minutes.

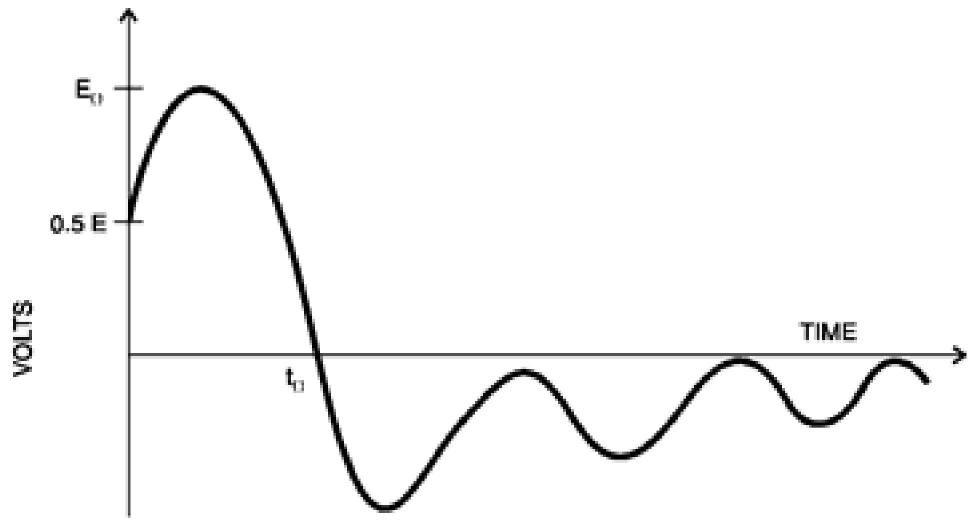


Figure 3.2.4.5.3-1. Representative positive transient waveform

3.2.4.5.4 Radiated Emissions, Magnetic Field

3.2.4.5.4.1 Radiated Emissions, AC Magnetic Field (RE01)

The Dewar's radiated AC magnetic field emissions shall be limited to the levels defined in Figure 3.2.4.5-6 when measured in accordance with the RE01 (7 cm) test methods of MIL-STD-462. The measurement bandwidth shall be as defined in Fig. 3.2.4.5.4.1-1.

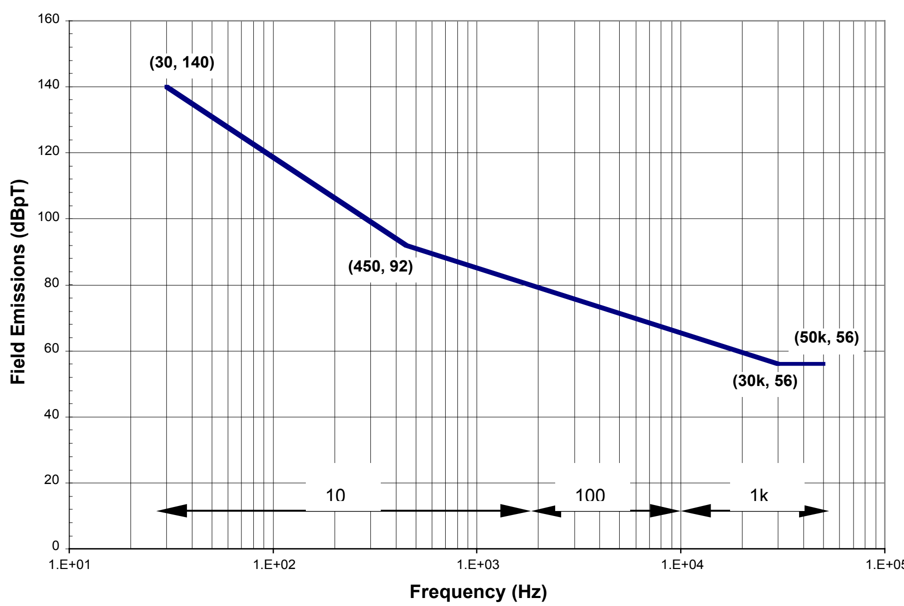


Figure 3.2.4.5.4.1-1. AC magnetic field radiated emissions (RE01) requirements

3.2.4.5.4.2 Radiated Emissions, DC Magnetic Field

The maximum dc dipole moment produced by the Dewar shall not exceed 0.5 A·m_ (**TBR**).

3.2.4.5.5 Radiated Emissions, Electric Field (RE02

3.2.4.5.5.1 Radiated Emissions, Narrowband Electric Field

The Dewar's narrowband radiated electric field emissions shall be limited to the levels defined in Figure 3.2.4.5-7 when measured in accordance with the RE02 test method of MIL-STD-462 over the frequency range of 14 kHz to 18 GHz. The measurement bandwidth shall be as defined in Figure 3.2.4.5.5.1-1.

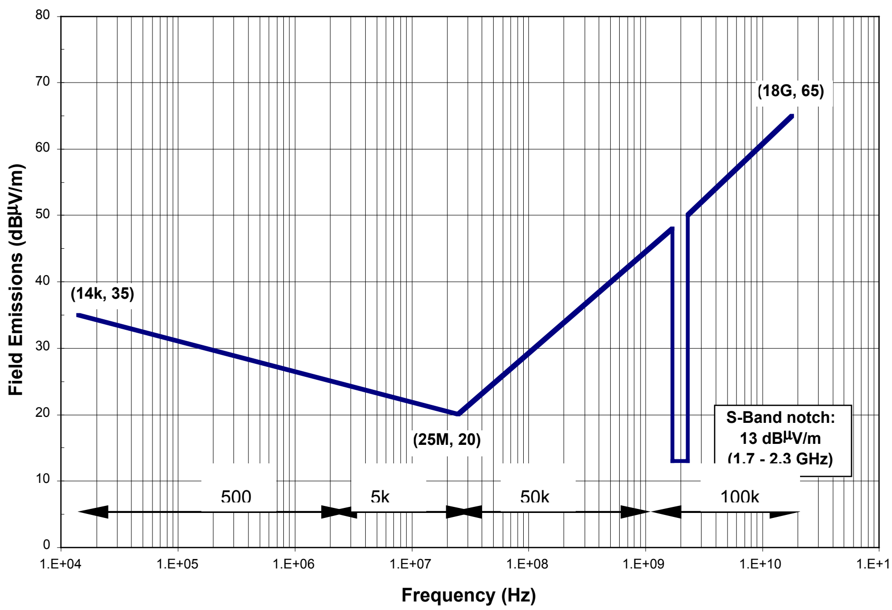


Figure 3.2.4.5.5.1-1. Allowable levels of narrowband electric field (RE02) radiated emissions

3.2.4.5.5.1 Radiated Emissions, Broadband Electric Field

The Dewar's broadband radiated electric field emissions shall be limited to the levels defined in Figure 3.2.4.5.5.1-1 when measured in accordance with the RE02 test method of MIL-STD-462 over the frequency range of 14 kHz to 18 GHz. The measurement bandwidth shall be as defined in Figure 3.2.4.5.5.1-1.

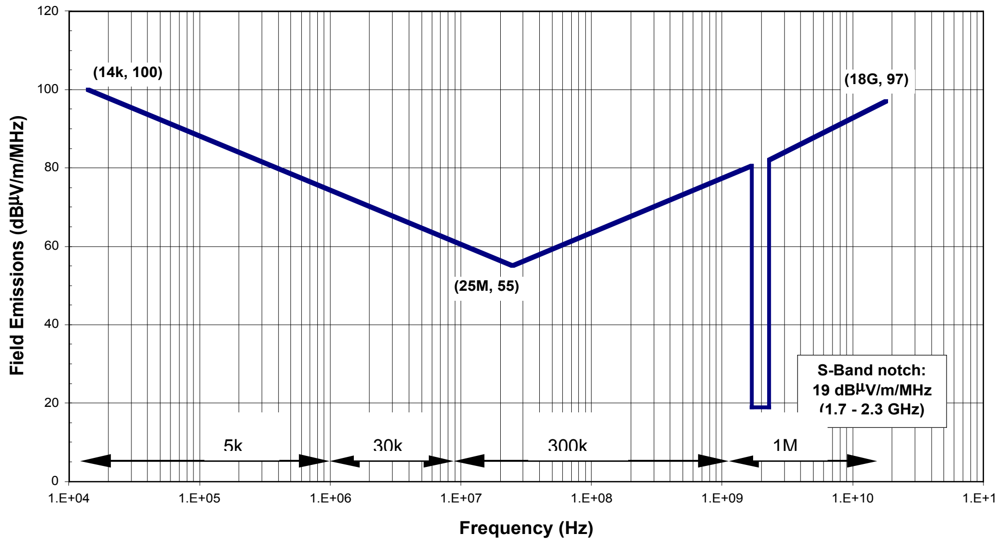


Figure 3.2.4.5.5.1-1. Allowable levels of broadband electric field (RE02) radiated emissions

3.2.4.5.6 Radiated Susceptibility, AC Magnetic Field (RS01)

The Dewar shall meet the performance requirements of this specification during exposure to the AC magnetic field defined in Figure 3.2.4.5.6-1 using the RS01 test method of MIL-STD-462. The Dewar shall meet the performance requirements during exposure to the radiated electric field defined in Table 3.2.4.5.7-1 below, using the RS03 test method of MIL-STD-462.

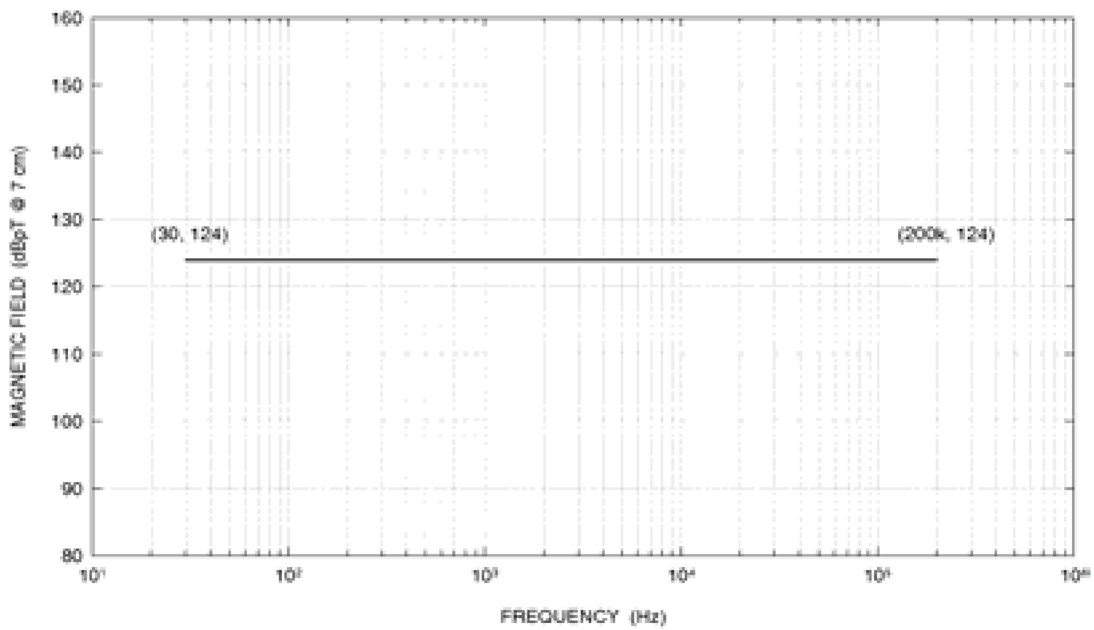


Figure 3.2.4.5.6-1. Dewar magnetic susceptibility environment

3.2.4.5.7 Radiated Susceptibility, Electric Field (RS03)

The Dewar shall meet the performance requirements of this specification during exposure to the radiated electric field defined in Table 3.2.4.5.7-1 using the RS03 test method of MIL-STD-462.

Table 3.2.4.5.7-1. Radiated Susceptibility, Electric Field, Levels (RS03)

Frequency			Electric Field Strength
14 kHz	to	2 GHz	2 V/m
2 GHz	to	12 GHz	5 V/m
12 GHz		18 MHz	10 V/m
	except:		
2.2 GHz		2.3 GHz	20 V/m
8.0 GHz		9.0 GHz	20 V/m

3.2.5 Operational

3.2.5.1 Startup/Shutdown Conditions

Dewar assemblies that contain any microprocessors, micro-controllers, FPGAs, memory devices, and/or digital circuitry shall startup and shutdown into known logic states in an orderly internal sequence. Neither power turn-on nor interruption shall produce commands or logic states that could cause failure, deleterious action, or re-configuration.

3.2.5.2 Abnormal Conditions

The Dewar Subsystem shall not incur damage from any of the following abnormal conditions, and shall meet all the performance requirements of this specification after a power-on reset and turn-on sequence following the removal of the abnormal condition.

3.2.5.2.1 Abnormal Input Voltage

The Dewar Control Electronics shall survive steady-state voltages in the range 0 V dc to 36 V dc and momentary (no greater than 10 ms) voltages in the range 0 V dc to 42 V dc.

3.2.5.2.2 Unannounced Power Loss

The Dewar Control Electronics shall meet the performance requirements of this specification after experiencing the unannounced removal and arbitrary reconnection of primary power.

3.2.5.2.2.1 Slow Power Rise/Drop-off

The Dewar Control Electronics shall meet the performance requirements of this specification after experiencing a slow voltage rise on turn-on or drop-off when the voltage falls below 20 V dc.

3.2.5.2.3 Unannounced Clock Signal Loss

The Dewar Control Electronics shall meet the performance requirements of this specification after experiencing the unannounced removal and arbitrary reconnection of the external synchronization clock signal.

3.2.5.2.4 Unannounced Command Interface Loss

The Dewar Control Electronics shall meet the performance requirements of this specification after experiencing the unannounced removal and arbitrary reconnection of the digital command interface.

3.2.5.3 Autonomous Operation

Following entering Control Mode per 3.1, the Dewar Subsystem shall be designed to perform nominal cooling without operator intervention for a period of up to 1 year.

3.2.5.3.1 Unattended Operation

The Dewar Assembly shall be capable of operating unattended for a minimum period of 48 (TBR) hours, while providing telemetry for anomalous conditions or errors that threaten safe operation. The Dewar assembly shall support the ISIM, C&DH, or S/C CTP response, which is to transition the MIRI instrument to safe mode until ground intervention can be established

3.2.5.4 Fault Protection

The Dewar Control Electronics shall detect and respond to critical faults or operating conditions that have the risk of immediately damaging the Dewar Subsystem or interfacing systems.

Note: S/C and ISIM fault protection scheme may introduce latency into response. Some critical functions may need more immediate response.

3.2.5.4.1 Tolerance to False Positives

Any built-in fault detection and automatic protection functions shall have features to greatly minimize the possibility of having a false positive due to a non-threatening disturbance. As a minimum, all fault protection functions shall be capable of being disabled by external command.

3.2.5.4.2 Safe Configuration

In response to a Dewar Control Electronics fault protection trigger, the Dewar Subsystem shall enter into a safe configuration from which it may recover with operator intervention; this mode may be the same as Standby Mode.

3.2.5.5 Operating Orientation

The Dewar Subsystem shall meet all performance requirements at nominalcryogenic operational temperatures in gravity orientations consistent with ISIM +V1 down, and zero-g.

3.2.5.5.1 Launch Orientation

The Dewar shall be prepared for launch and launched in the ISIM +V3 up orientation. Any effect of orientation on performance shall be quantified.

3.2.5.5.2 Test Operating Orientation

The Dewar shall be fully functional for testing purposes in any orientation.

3.2.5.6 Functional Testing

3.2.5.6.1 Thermal-Vacuum Test

The Dewar shall be capable of cooling its TSIs in test using liquid helium as the cryogen.

Note: Additional accommodations for heaters during test may be required to help the MIRI OBA reach its functional temperatures.

3.2.5.6.2 Short Functional Test

The Dewar Subsystem shall be capable of demonstrating the health of its principal functions and interfaces in a test at ambient temperature and pressure and lasting less than TBD (30) minutes.

3.2.5.7 Electrical Ground Test Equipment

The electrical ground test equipment shall operate the Dewar Subsystem at various levels of assembly during ground tests.

3.2.5.7.1 Electrical Ground Support Equipment (EGSE)

During ground testing the EGSE will be used to provide power and communications to the Dewar Control Electronics assembly. It shall contain the functions necessary to safely operate the complete Dewar Subsystem through all operational modes during ground operations, provide S/C power and signal communications interfaces with the Dewar Control Electronics, and provide user data display and command entry interfaces with the human operator.

3.2.5.7.2 Dewar Housekeeping Electronics (DHE)

During ground testing the DHE, a DCE simulator, will be used to monitor and control the Dewar or the ETU Dewar for ground operations and when a Dewar Control Electronics assembly is unavailable. The DHE shall carry out the drive and control functions of the Dewar Control Electronics assembly as well as the user command entry interface and display functions of the EGSE.

3.2.5.7.3 Input Power

The DHE and EGSE shall operate from 110 V, 60 Hz AC power and 220V 50Hz.

3.2.5.7.4 Features of Electrical Ground Test Equipment

The EGSE shall both include as a minimum the following components to monitor and operate the Dewar Subsystem during ground testing.

a. Hardware and software to simulate the nominal power input to the Dewar Control Electronics.

b. Hardware and software to simulate all external command and data monitoring of the Dewar Subsystem performance that would be expected during ground and space operation.

c. Temperature sensors, heaters, and temperature controllers to monitor and control the Dewar and TSI temperatures.

d. True-rms power meters to monitor the power supplied to the Dewar Control Electronics STM and FM (BE and EGSE), and EM electronics (EGSE only).

e. Control and monitoring of any ground operating valves (DHE).

3.2.5.7.5 Ground Test Interlocks

The BE and EGSE shall incorporate provisions to protect the Dewar Subsystem from damage. These shall include as a minimum the following:

1. Automatic shutdown of any heaters in the event of excessive temperatures.
2. Automatic shutdown of the Dewar Subsystem in the event of excessive Dewar Control Electronics assembly temperatures.
3. Interlocked control over all valve operations.

3.2.5.8 Mechanical Ground Test Equipment

The mechanical ground test equipment shall provide necessary mechanical support functions to the Dewar at various levels of assembly during ground tests.

3.2.5.8.1 Cryogenic Service Equipment (CSE)

The CSE shall perform all necessary vacuum, purge, fill, and chill services for cooling the Dewar from ambient to operational temperatures. The CSE shall be rated for, and compatible with hydrogen, and include control and instrumentation for monitoring the vent, fill and topping-off operations associated with the Dewar Subsystem.

3.3 DESIGN AND CONSTRUCTION

The Dewar design shall be single-fault tolerant in accordance with JPL D-25631, Mission Assurance Plan.

3.3.1 Parts, Materials and Processes

Comment: All flight Dewar parts, materials, and processes shall be proven for space applications, as evidenced by either 1) appearing in a preferred selection list cited in this specification, or 2) successfully completing a dedicated evaluation program to assess its capability to meet the requirements of its intended use.

3.3.1.1 Materials

The Dewar shall use only materials rated "A" in MSFC-HDBK-527 for flammability, thermal vacuum stability, stress corrosion cracking, corrosion, and, if applicable, high pressure hydrogen compatibility.

3.3.1.1.1 Forbidden Materials

The following materials shall not be used: mercury, polyvinyl chloride, carcinogenic or toxic materials, radioactive sources, shatterable or flaking materials, cadmium, and zinc.

3.3.1.1.2 Material selection

Material selection shall relate directly to the results of the contamination analysis.

3.3.1.1.3 Materials List

A Materials Identification and Usage List (MUIL) identifying all materials and processes used in the fabrication of the Dewar shall be prepared by the Dewar contractor and submitted to JPL for review.

3.3.1.2 Electronic Parts

The Dewar Control Electronics shall use only JPL Standard Parts, which are identified as electrical, electronic and electromechanical (EEE) parts that meet or exceed the following two sets of reliability standards:

3.3.1.2.1 Single Point Failure Applications

The following are standard parts in single point failure applications:

a) NPSL Level 1

b) MIL-PRF-38534 Class K, QML-38534.

c) MIL-PRF-38535 Class V, QML-38535, (MIL-M-38510, Class S).

d) MIL-PRF-19500 JANS, QPL-19500.

e) Military Established Reliability (ER) passive devices, Failure Rate Level S.

3.3.1.2.2 Single Point Failure Tolerant Applications

The following are standard parts in single point failure tolerant applications:

a) NPSL Level 2

b) MIL-PRF-38534 Class K, QML-38534 (Level 1).

c) MIL-PRF-38535 Class Q, QML-38535, (MIL-M-38510, Class B).

d) MIL-PRF-19500 JANTXV, QPL-19500.

e) ER passive devices, Failure Rate Level R (Level 2).

3.3.1.2.3 Custom Hybrid, MCM and HDI Microcircuits

Hybrid devices designed and fabricated by non-QML sources, such as JPL or their non-QPL contractors, shall be in conformance with requirements of Class K reliability level of MIL-PRF-38534 with a 10 piece element evaluation for each die device type. Pre-cap visual inspection and document review(e.g. element evaluation, burn-in data and rework travellers) prior to seal is required for all hybrids. All non-QML sources and APL contractors will be on JPL's Approved Suppliers List (APL).

Substrates used for custom hybrids (as defined above) shall be subjected to additional screening to include:

Table 3.3.1.2.3-1. 100% Screening Requirements for Substrates including samples used for qualification

Test	Method	Condition	Quantity
Temperature Cycling	1010	E, 10 cycles@-65°C to 300°C	100%
Electrical testing		Per schematic	100%
*Acoustic Microscopy	JEDEC Std-035	All internal features meet specified substrate design requirements	100%
Radiographic	2012	All internal features meet specified substrate design requirements	100%

*Most Acoustic Microscopy techniques require a medium, such as de-ionized water, to propagate the sound waves that surrounds the substrate. If moisture is a concern, perform this test as a qualification.

Table 3.3.1.2.3-2. Table Qualification Requirements for Substrates on at least a sample of 2 substrates

Test	Method	Condition	Quantity
Cross-section*	Defined by the Hybrid Specialist		2
High temperature aging with additional adhesion testing	Defined by the Hybrid Specialist		2

*Perform sufficient cross-sections and inspect under high magnification to verify all internal features meet specified substrate design requirements.

The JPL Hybrid Parts Specialist shall identify in-process inspection points that ensure adequate yield per project needs. Inspection points will be called out in the travelers and inspected by QA.

3.3.1.2.4 Non-Standard Parts Approval

Any electronic parts that do not meet the definition of Standard Part, as defined above, are considered non-standard parts. Design organizations intending to use non-standard parts must submit a Non-Standard Parts Approval Request (NSPAR). Non-standard parts may only be used if the NSPAR is approved by JPL.

3.3.1.2.5 Parts List Reviews

All electronic parts lists shall be submitted to JPL in an electronic format. Parts lists provided by JPL hardware developers, contractors, and suppliers shall be submitted for review and approval. It is recommended that an initial parts List must be submitted as soon as a meaningful list is available. JPL hardware developers, contractors, and suppliers shall provide preliminary parts lists 1 month prior to the subsystem preliminary design review (PDR). Revisions to preliminary parts list are to be provided whenever updates are entered. Deltas to the previously submitted parts list should be highlighted. JPL hardware developers, contractors, and suppliers shall provide as-designed parts lists 1 month prior to the subsystem critical design review.

3.3.1.2.6 Parts Acquisition

3.3.1.2.6.1 *HERITAGE PARTS*

Residual inventory (i.e., heritage parts), in this context, refers to parts previously approved and procured for prior flight Project applications. Residual electronic parts will be reviewed and subsequently be employed by MIRI hardware developers after it is determined that the parts meet the requirements of this document.

3.3.1.2.6.2 *PARTS PROCUREMENT*

Purchase orders shall not take exception to reference specifications or requirements therein unless approved by the JPL MIRI Electronics Parts Engineer (EPE) or via waiver. All parts suppliers shall be on JPL's ASL.

3.3.1.2.6.3 *CUSTOMER SOURCE INSPECTION*

Pre-seal visual inspection shall be performed on all packaged flight ASICs, hybrid microcircuits, Multi-chip Modules, crystal oscillators, and nonstandard relays. Source inspection/pre-cap inspections will be coordinated with the JPL QA group.

3.3.1.2.6.4 *RADIATION LOT ACCEPTANCE TESTING (RLAT)*

Device types that are known or shown to be marginal by a TID characterization test or analysis, if still requested for use in flight equipment, shall be subjected to RLAT. The RLAT specifications and requirements shall be reviewed and approved by the Project cognizant engineer(s), JPL's EPE and Parts Radiation Specialist, prior to start of testing. Radiation related

TID testing and evaluations shall be done in accordance with MIL-STD-883, Method 1019.4, or per recommended test methodology found in JPL D-18002, Radiation Test Requirements for Ionization and Displacement Damage, or JPL-approved contractor equivalent. Other radiation related testing, if required, shall be performed as described in Radiation Effects Requirements of this section. All CMOS devices shall be subjected to RLAT for SEL per the SEL requirements of this section, unless there is evidence of lot specific test data, manufacturer's certification and/or the wafers were produced at foundries with QML or process controlled lines.

3.3.1.2.6.5 *DESTRUCTIVE PHYSICAL ANALYSIS (DPA)*

Grade-2/Class-B (Level 2) packaged electronic parts require DPA per SSQ25000. DPAs shall also be performed on a sample of each manufacturing lot date code for all crystal oscillators, filters, ceramic capacitors (except MIL-C-123), relays, MIL-C-39010 inductors, and all nonstandard packaged parts (including multi-chip modules and hybrids), regardless of procurement to Grade-1/Class S/Class K (Level 1) levels. MIL-C-39010 inductors/transformers shall be sectioned to examine the adequacy of the termination. Relays shall have an internal visual examination. Chip capacitors and resistor networks require a DPA. The results of the DPA shall be evaluated by the procuring activity, and the lot shall be accepted or rejected based on the criteria of the specification.

3.3.1.2.7 AS-BUILT PARTS LIST

An As-Built Parts List shall be released prior to hardware integration and test. In addition to the information required in the Preliminary Parts Lists, the As-Built Parts List shall include for each different part:

a) The actual part marking

b) Part number purchased

c) Manufacturer

d) Lot date code

e) Serial number (for serialized parts)

f) Wafer and wafer lot numbers (when applicable)

g) Parts test lot numbers (where applicable)

h) Procurement specification number

i) Traceability number (when assigned by the cognizant parts organization)

j) The serial number and part number of the next assembly level into which the part is installed (e.g., board or module)

k) The reference designator of the location where each party is used on the next assembly level.

The as-built parts list shall be supplied to the EPE in a computer-readable format. The EPE will ensure that all as-built parts lists will remain accessible throughout the duration of operations.

3.3.1.2.8 Electronic Parts Derating

Dewar EEE parts shall be derated for electrical stress and temperature per the JPL D-8545 derating criteria for that part in that application.

3.3.1.2.8.1 Electrostatic Discharge Protection

Dewar EEE parts shall be protected from Electrostatic Discharge (ESD) damage or degradation in handling and storage by the methods of JPL D-1348, or JPL-approved equivalent.

3.3.1.2.8.2 Electronic Part Failure Analysis

Dewar EEE part failures, including failures during screening but excluding parts damaged by human error (e.g., improper installation), shall be subjected to failure analysis, carried to the point that lot dependency of the failure mode can be determined.

3.3.1.2.8.3 Electronic Part Traceability

Dewar EEE parts shall be traceable to a specific manufacturer, part number, lot number/date code, serial number, and its associated parametric test and evaluation data.

3.3.1.2.8.4 Defective Electronic Part Notifications

The Dewar shall not use defective EEE parts identified in Government Industry Data Exchange Program (GIDEP) Alerts or NASA Advisories. For additional information, see JPL D-25631, Section 7.8.3.

3.3.1.3 Electronic Packaging

Flight electronics shall be packaged using qualified space-rated electronic packaging techniques designed for vacuum operation and conductive heat transfer to the external heat-rejection surface. Preferred packaging concepts are defined in JPL D-8208.

3.3.1.3.1 Thermal Cycle Endurance

Flight printed wiring board assemblies, with all process elements including component mounting (with any heat sinking), soldering method, and conformal coating, shall be capable of surviving 100 thermal cycles from +100 °C to -35 °C, without experiencing failures such as cracked PWB elements or cracked solder joints.

Note: Demonstration of required endurance is not performed on flight hardware, but on flight-like hardware comprised of flight-like parts assembled using flight fabrication and assembly processes.

3.3.1.3.2 Minimum Circuit Board Resonant Frequency

Flight printed wiring boards, when installed in their mounting structure and populated, shall have a resonant frequency greater than 250 Hz, with >350 Hz as a goal.

3.3.1.3.3 Electronic Part Maximum Junction Temperatures

Dewar EEE parts shall have a maximum junction temperature of less than 110°C during Protoflight-Operating heatsink conditions defined in 3.2.4.3.1.

3.3.1.4 Connectors

3.3.1.4.1 Keying

The Dewar shall use connectors of different sizes, different types, or uniquely keyed to prevent improper connection during Dewar integration.

3.3.1.4.2 Connector Types

The Dewar shall use connectors selected from JPL-STD-00009, or JPL-approved equivalent.

3.3.1.4.2.1 Blind Connector Mating

The design shall avoid the use of “blind; mating of electrical connectors.

3.3.1.4.2.2 Connector Selection

All connectors shall be selected from the GSFC PPL-21 or an equivalent ESA PPL, as defined in the JWST Product Assurance Requirement (JWST-RQMT-000650).

3.3.1.4.2.3 Keying

Connectors on a given surface shall be sized, oriented, keyed, or otherwise protected from an improper connection that would result in damage to equipment connected to either end of the harness.

3.3.1.4.2.4 Accessibility

All connectors shall be accessible for mate/demate without removal of any adjacent objects (components, parts, bolts, etc.).

3.3.1.4.2.5 Accessibility

When the box is stand-alone, all connectors shall be accessible for mate/demate without the use of any custom tools.

3.3.1.4.2.6 Clearances

Circular connectors shall have a minimum of 20mm clearance provided around the outside of mated connector plugs.

3.3.1.4.2.7 Clearances

Rectangular connectors shall have a minimum of 20mm clearance at the end of the connector body and 2mm clearance above and below the connector body.

3.3.1.4.2.8 Procurement

The Contractor shall be provided the mating connector at an interface by the owner of the other side of the interface (GFE).

3.3.1.4.2.9 Application

Separate connectors shall be used for each of the following: primary power, MIL-STD-1553B, Test connection, discrete interfaces, primary and redundant sides of the above interfaces.

3.3.1.4.2.10 Identification

All connectors shall be clearly marked with a unique identifier.

1. The Dewar assembly shall identify each connector with a designator starting with the letter "J" followed by a unique 4-digit number (TBR), e.g. "J0001."
2. Connector designators shall use sequential 4-digit numbers (TBR) starting with J0001.
3. The harness connectors that mate with the MIRI subsystem assembly shall be identified with the appropriate subsystem assembly reference designator followed the connector reference designator. The harness connector reference designator shall start with the letter "P" followed by the same 4-digit number (TBR) as the assembly mating connector, e.g. "P0001."
4. The Dewar-MIRI ICD shall include a connector definition table for each Dewar subsystem assembly that includes the assembly reference designation, connector identifier, and connector function.
5. The Contractor shall provide to JPL a connector definition table for the Dewar assembly that includes the assembly reference designation, connector identifier, and connector function.
6. The Contractor shall provide to JPL a pin definition table for each Dewar assembly connector. This table includes the connector identifier, pin number, signal name, and wire type.

3.3.1.4.2.11 Connector Savers

Connector savers shall be utilized on all flight connectors (both harness and bulkhead sides) prior to final connector/harness mate for flight during ISIM/Observatory I&T.

3.3.1.4.2.12 Protective Covers

All connectors, when not mated, shall have either protective covers installed, or shorting connectors installed depending upon the function of the connector.

3.3.1.5 Harnesses

The Contractor shall provide the specification for the harness to connect the Dewar assembly to the Dewar Control Electronics and any needed test harnesses. The total harness length between the DCE and the Dewar shall be less than 6m (TBR).

3.3.2 Isolation, Grounding, and Shielding

3.3.2.1 Chassis Ground

The Dewar Control Electronics shall be designed such that all primary, secondary, and signal return currents return though dedicated wires back to their source. The Dewar shall not use chassis ground to conduct power currents.

Comment: Only fault, and leakage currents should be conducted through chassis grounds.

3.3.2.1.1 Grounding Point

The Dewar shall provide an external grounding point for connection to the grounding interface.

3.3.2.2 Primary Power Isolation

The Dewar primary power (28 V dc) leads and returns shall be isolated from signal and chassis ground by no less than 1 MΩ (dc).

3.3.2.3 Secondary Power Isolation

The Dewar secondary power shall be isolated from primary power by no less than 1 MΩ (dc) and shall use a single point ground to the electronic chassis.

3.3.2.4 Chassis-Connector Resistance

The body of each chassis connector shall be electrically connected to the chassis with a DC resistance less than or equal to 10 mOhm.

3.3.2.5 Signal Conductor Shielding

The Dewar signal interfaces shall use shielded conductors, which may include shielded twisted pair, coaxial, twin axial, and dual coaxial types.

3.3.3 Mechanical Design Requirements

The Dewar design shall take into account on-ground testing requirements.

3.3.3.1 Minimum Resonant Frequency

The Dewar Assembly and any other component with a mass greater than 25kg configured for launch, including KMs, shall have a minimum fixed-base resonant frequency of no less than 50 Hz.

3.3.3.1.1 Components Less Than 25 Kg – Fixed-Base Frequency

Each separately mounted MIRI component with a mass less than 25 Kg configured for launch, including mounting brackets, shall have a fixed-base frequency of greater than 100 Hz.

3.3.3.2 Venting and Purge

The number, location, size, vent path, and operation time of vents shall be designed as follows:

3.3.3.2.1 Location of Fill and Vent Interfaces

The number, location and size of fill and vent paths shall be as indicated in the Dewar-MIRI ICD.

3.3.3.2.2 Vent Operation Time

The flow through the vents as a function of time shall be provided (to JPL) and included in the Dewar-MIRI ICD.

3.3.3.2.3 Venting Torque and Force

The resulting torque (around all axes) and linear force produced by cryogen boil-off venting during all mission phases shall be calculated and included in the Dewar-MIRI ICD.

3.3.3.2.3.1 Constant Disturbance Torque Limits

TBD

3.3.3.2.3.2 Periodic Disturbance Torque Limits

TBD

3.3.3.2.3.3 Constant Linear Forces Disturbance Limits

Constant linear force during steady state venting of the Dewar shall be less than 0.1 dynes (TBR) in any direction.

3.3.3.2.3.4 *Launch Venting*

The Dewar venting (all components) shall be compatible with the Launch Pressure Profile given in 3.2.4.2.2.

3.3.3.2.4 Dewar Vent Valve

3.3.3.2.4.1 Dewar Vent Valve Control

Accommodations to permit control of the Dewar Vent Valve opening from the DCE upon receipt of a command from the SC CTP shall be provided.

3.3.3.2.4.2 Dewar Vent Valve Open Command

The DCE shall issue the control signals to open the Dewar Vent Valve TBD (minutes) after launch and faring separation.

3.3.3.2.4.3 Dewar Vent Valve Indication

An indication of the Dewar Vent Valve position (open or closed) shall be made available to the SC CTP.

3.3.3.3 TSI Applied Force Capability

The force allowable to be applied to the TSI by the attached thermal straps during all phases of the mission shall be provided as part of the Dewar-MIRI ICD.

3.3.3.4 Launch Restraint Devices

Dewar subsystem devices that cage, dampen, clamp, or latch other Dewar mechanisms that require such restraint during launch shall

a. Require no power to maintain the constrained condition,

b. Be capable of at least 500 engage-disengage actuations,

c. Provide the remote human operator with positive knowledge of the constrained-versus-unconstrained status of the device,

d. Provide ground support restraint arrangements (e.g., motor shorting plugs) if the launch restraint device is removed or deactivated during Dewar subsystem ground handling, transportation, or vibration testing.

e. Be capable of being caged and uncaged by remote command, and

f. Be caged no earlier than TBD hours before launch and uncahged no more than TBD hours after launch.

3.3.3.5 Leak Rate

The total Dewar leak rate inside the cryostat, either from external air, when applicable, or from the cryogen system shall not adversely affect the Dewar performance given the ground handling processing of the Dewar.

3.3.3.6 Mechanical Assembly Thermal-Cycle Endurance

The Dewar subsystem and piping assemblies shall be capable of surviving 25 (TBR) thermal cycles from +35 °C to the lower Flight Allowable Operating temperature per Table 3.2.4.3-1 without experiencing failures such as leaks or loss of critical alignments.

Note: Demonstration of required endurance is not performed on flight hardware, but on flight-like hardware comprised of flight-like parts assembled using flight fabrication and assembly processes. The demonstration can be done at the subassembly or part level.

3.3.3.7 Piping Assembly Field Joints

The Dewar subsystem shall have disconnectable field joints to allow integration within the ISIM enclosure.

3.3.3.7.1 Field Joint Disconnect-Reconnect Cycles

Each field joint in the Dewar piping shall be capable of no less than 10 successful disconnect-reconnect cycles after initial installation.

3.3.3.8 Dewar Structure

The Dewar structure shall be mounted to the ISIM structure using a set of four KMs (bearings/flexures).

3.3.3.8.1 Dewar Lifting Points

The Dewar structure shall provide the lifting points and transportation interfaces for handling, integration, test, and transportation of the Dewar assembly.

3.3.3.8.1.1 Dewar Component Lifting Points

Lifting points shall be incorporated into all MIRI components weighing in excess of 16 kg.

3.3.3.8.2 Dewar Structural Design

The Dewar supplier shall be responsible for the structural design and analysis of the Dewar with the thermal straps attached. Full mechanical information related to the thermal straps shall be provided to the Dewar developer to accomplish this analysis, and this analysis shall be documented in the Dewar-MIRI ICD.

3.3.4 Electrical Interface Requirements

3.3.4.1 Dewar Control Electronics

The contractor shall provide Dewar Control Electronics (DCE) to control the Dewar.

3.3.4.1.1 DCE Redundancy

The DCE shall be functionally redundant at the board or circuit level.

3.3.4.1.2 DCE Location

The DCE shall be located in Region 2 of the Observatory

3.3.4.1.3 DCE – Launch Critical Commands

The DCE shall respond to launch critical commands (e.g. vent valve) from the SC CTP.

3.3.4.1.4 DCE – Launch Critical Telemetry

The DCE shall send launch critical engineering telemetry to the SC CTP.

Note: The Interface between the DCE and the SC CTP is RS-422. (TBR)

3.3.4.1.5 DCE – Response to ICDH

After full activation (i.e. after the launch phase), the DCE shall respond to configuration commands from the ICDH.

3.3.4.1.6 DCE – Post-Launch Telemetry to ICDH

After full activation (i.e. after the launch phase), the DCE shall send engineering telemetry to the ICDH.

3.3.4.2 Primary Power

3.3.4.2.1 Power Filtering

The Dewar shall use inductors with a distributed gap, (e.g., a powder core) for power filtering, not inductors with hard gaps.

3.3.4.2.2 Suppression Devices

The Dewar shall use suppression devices at the source of the inductive transients, such as diodes across all relay coils or other energy sources that could induce transients on the power lines during turn-off.

3.3.4.3 DCE Interface Telemetry – Resistance Measurement

The resistance measurements shall be made with an excitation voltage small enough to limit self heating in the devices being measured.

3.3.4.4 DCE Interface– Heater Drive Power Range

The heater driver power (if any) shall be command able with a resolution of 5% of the maximum power, and an accuracy of better than 10%.

3.3.5 Command and Data Handling Requirements

3.3.5.1 Command Response

The Dewar shall respond to valid commands received over the command interface (CTP or ICDH).

Comment: The list of valid commands will be documented in the Dewar command dictionary.

3.3.5.1.1 Dewar Vent Valve Open Commands

The DCE shall have the capability of accepting and executing separate commands to open the Dewar vent valve(s).

3.3.5.1.2 Dewar Vent Valve Status

The DCE shall send an indication of the vent valve status (open or closed) to the spacecraft CTP.

3.3.5.1.3 Dewar Vent Valve – Redundant Circuitry

The DCE shall provide independent, redundant circuits for opening the vent valve(s).

3.3.5.1.4 Dewar Heat Switch On/Off Commands

The DCE shall have the capability of accepting and executing commands to Open and Close the Dewar heat switches.

3.3.5.1.5 Dewar Heat Switch Heaters

The DCE shall control the heat switches to keep the heat switches Open during the initial MIRI cool-down until the MIRI OBA temperature has cooled below 70K (TBR).

3.3.5.1.6 Dewar Heat Switch Heaters

The DCE shall control the heat switches and Open or Close the heat switches upon command from the ISIM IC&DH.

3.3.5.2 Command Constraints

3.3.5.2.1 Toggle Commands

The Dewar Assembly shall not use state-dependent or "toggle" commands.

3.3.5.2.2 Critical Commands

The Dewar shall, as a minimum, use separate enable and execute commands to initiate and complete critical or hazardous functions (i.e., Vent Valve Open; Heat switch activation) to prevent inadvertent execution of these commands.

3.3.5.2.3 Override of Automatically Triggered Functions

The Dewar shall have commands available to override all functions automatically triggered by software.

3.3.5.2.4 Command Execution Verification

The Dewar subsystem shall be capable of verifying command execution via telemetry.

3.3.5.2.5 Wrong Commands

The functionality and performance of the Dewar Assembly shall not be permanently degraded by execution of the wrong command.

3.3.5.2.6 Command Response

The Dewar shall have checks in place to verify all valid commands, and report all valid and invalid commands.

3.3.5.3 Data Message Response

The Dewar subsystem shall output a data message in response to a valid data-request command received over the command interface.

Comment: The list of valid data messages is expected to include as applicable: interface temperature monitor (coarse or fine), power supply temperature, secondary voltage monitors, , checksums on memory data, memory data readout of a specified address range, software version, and other data messages to be defined by the Contractor and JPL.

3.3.5.3.1 Dewar Sensor Data to CTP

The DCE shall monitor and send to the spacecraft CTP a subset of the Dewar sensors for launch critical monitoring of the health of the Dewar.

3.3.5.3.2 Dewar Sensor Data to ISIM IC&DH

The DCE shall monitor and send to the ISIM IC&DH sufficient Dewar temperature sensors (as defined by the Dewar vendor) to monitor the health and performance of the Dewar during the JWST mission.

3.3.5.3.3 Heat Switch Temperature Sensor Data to ISIM IC&DH

The DCE shall monitor and send to the ISIM IC&DH the heat switch temperature sensors to monitor the status and performance of the heat switches.

3.3.5.4 Response Time

The Dewar subsystem shall start transmission of normal telemetry less than 10 s after the receipt of a data-request command.

3.3.6 Software Requirements

3.3.6.1 Programming Language

All Dewar subsystem software shall be implemented using standard Ada (MIL-STD-1815), C (ANSI X3.159), or C++ (follow GSFC guidelines – TBR)with the following exceptions. Nonconforming C extensions may be used to meet performance goals in the freestanding environment. Assembly language may be used where performance requirements cannot be met for time-critical functions. With the exception of programmable read-only memory (PROM) resident software, assembly language shall not be used without JPL approval. All cases where assembly language is deemed necessary shall be clearly identified.

3.3.6.2 Version Control

All Dewar control electronics software and firmware shall be implemented with an internal identifier (embedded in the executable program) that can be included in the data message. This identifier shall be keyed to the configuration management process so that the exact version of software and firmware residing in the Dewar subsystem can be determined at any time.

3.3.6.3 In-flight Installation and Verification

The Dewar subsystem software shall be in "firmware" so that it can not be modified in-flight.

3.3.6.4 In-flight Permanent Storage

The Dewar control electronics shall carry a copy of the Dewar subsystem software.

3.3.6.5 Random Access Memory Margin

At the end of the EM electronics development process, the random access memory (RAM) margin shall be no less than 50 %.

3.3.6.6 Fault Diagnosis

The DCE shall implement fault protection techniques associated with vent valve and heater operations (Details TBD).

3.3.7 Contamination Control

3.3.7.1 Baseline Surface Cleanliness

As a baseline, external surface particulate contamination shall be Level 300 (TBR) and surface molecular contamination shall be Level A (TBR) according to the Product Cleanliness Levels and Contamination Control Program , MIL-STD-1246, or better, at delivery.

3.3.7.1.1 Clean Room Compatibility.

The Dewar subsystem shall be compatible with continuous operation in a Class 10,000 or better (ISO 14644-1 Class 7 or better) clean work area.

3.3.7.2 Surface Cleanability

The Dewar exterior surfaces shall be readily cleanable with ethyl alcohol using standard wipe techniques to maintain a surface cleanliness of 300 A (TBR) per MIL-STD-1246 without permanent degradation to the Dewar. Dewar subsystem assemblies that are sealed and vented with appropriate filters, such as electronic boxes, may exceed the Level 300 particulate requirement; however, the Level A nonvolatile residue (NVR) requirement must be met.

3.3.7.2.1 Cleaning Responsibility

The Dewar provider shall be responsible for cleaning the Dewar.

3.3.7.3 Molecular Outgassing

The MIRI Dewar outgassing rate shall be measured at a MIRI vent at no greater than TBD g/cm^2/hr with the MIRI dewar at the hot thermal qualification temperature and the measuring device at 77K, or less.

3.3.7.4 Material Outgassing, Volatile Condensation

Dewar subsystem materials exposed to space vacuum shall have collected volatile condensable material (CVCM) of less than 0.1 % when tested in accordance with ASTM E595-93 or equivalent method.

3.3.7.5 Internal Cleanliness

Internal particulate contamination shall be controlled to a level that will achieve operational life of the Dewar (Consideration shall be given to all hardware components: i.e., valves – filter stages, specially cleaned cryogen, heaters to remove condensables; etc.).

3.3.7.6 Device Contamination Requirement

Electro-explosive devices (EEDs), hot-wax switches, or other devices shall be sealed devices that do not allow escape of the actuating materials.

3.3.8 Human Performance/ Human Engineering

Human performance shall be considered in the design process, material processing, testing, and all phases of design, development, and operation. Particular attention shall be given to requirements for the installation and removal of subassemblies from the Dewar subsystem using mating connectors and any repair/replacement or maintenance procedures.

3.3.9 Safety

The Dewar shall adhere to the applicable design requirements of JPL Standard for System Safety (JPL D-560).

3.3.9.1 Ground, Launch Site, and Launcher Facility Safety

The Dewar and its ground support equipment shall comply with the safety requirements of the ground facilities, the launch site facilities, and the launcher (specified in CSG-RS-10A-CN, CSG-RS-21A-CN, CSG-RS-22A-CN).

3.3.9.2 Spacecraft/Launch Vehicle Preparation and Operational Constraints

The Dewar and its ground support equipment shall be compatible with the spacecraft/launch vehicle preparation rooms and the operational constraints at the launch site (specified in the Ariane 5 Users Manual).

3.3.9.3 Fill, Vent, and Purge Safety

The Dewar design shall ensure correct and safe functioning of the cryogen fill, vent, and purge system by providing an adequate number of valves and safety-devoted components, such as pressure relief valves and burst discs.

3.3.9.4 Attachment Hardware

All items to be installed, removed, or replaced at the ISIM/Observatory integration level shall utilize captive hardware , except MIRI mounting hardware.

3.3.10 Structural Design Criteria

Structural support shall be provided for all the Dewar components such that major component loads transmitted across the interface into the MIRI does not exceed the design limit loads depicted in Figure 3.3.9.1.3-1 for Dewar subsystem design.

3.3.10.1 Margins of Safety

All structures shall have a predicted margin of safety greater than zero for design and qualification loads.

3.3.10.2 Application of Limit Loads

Limit loads shall be applied at the center of mass of each MIRI component (Dewar, DCE), configured for launch, to design the mounting interface.

3.3.10.2.1 Limits at the ISIM Interface

The MIRI shall be designed to support all forces and moments at each attachment location generated by the application of the design limit loads assuming both a rigid and flexible ISIM interface. Stiffness values at the ISIM interface will be provided by JPL.

3.3.10.2.2 Direction of Applied Limit Loads

The loads shall be applied in any direction in such a way as to produce the maximum stresses at the interfaces.

3.3.10.2.3 Limit Loads Based on MAC

The limit loads shall be based on the mass of the MIRI component as defined in Figure 3.3.10.2.3-1.

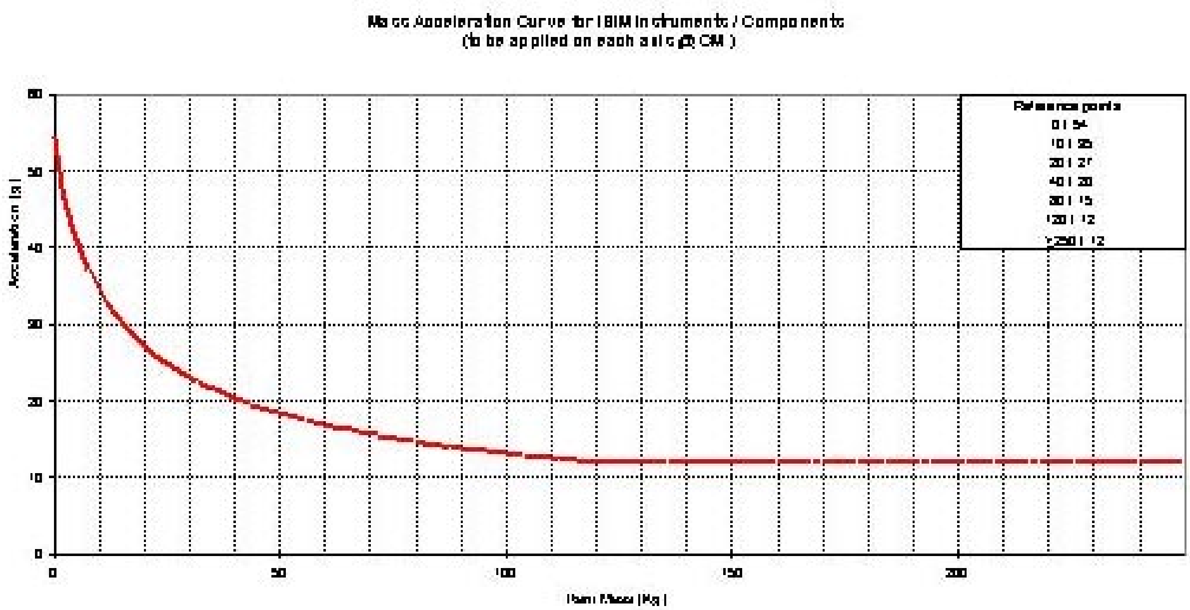


Figure 3.3.10.2.3-1. Design Limit Load vs. Dewar Component Mass

3.3.10.2.4 Factors of Safety

The design or analysis loads shall be determined by multiplying the design factors-of-safety (FS) specified in Table 3.3.10.2.4-1.

Table 3.3.10.2.4-1. JWST - ISIM Design Factors-of-Safety

Design FS	Static	Sine	Random/Acoustic	Shock
Metallic Yield	1.25	1.25	1.6 rms	
Metallic Ultimate	1.4	1.4	1.8 rms	
Stability	1.40	1.40	1.8 rms	
Beryllium Yield	1.40	1.40	1.8 rms	
Beryllium Ultimate	1.60	1.60	2.0 rms	
Composite Ultimate	1.50	1.50	1.9 rms	
Bonded HC Inserts	1.50	1.50	1.9 rms	
Shock Response Spectra				3 dB/ 6 dB

3.3.10.3 Non-Beryllium Structural Elements

All non-beryllium (this includes non-metallic composite and metal matrix structural elements) primary and secondary structural elements shall undergo a strength test to 1.25 x limit loads.

3.3.10.4 Pressure Systems

The Dewar pressure containment structure shall be designed in accordance with the requirements of ANSI/AIAA S-080-1998 or ANSI/AIAA S-081-2000; and have adequate strength for all mission phases using a minimum analytical FS of

a. 4.0 for diameters of less than 3.81 cm or

b. 2.5 for diameters of 3.81 cm or greater.

Notes:

1. The above FS are for ultimate relative to maximum operating pressure, per paragraph 5.3.1 of MIL-STD-1522A.

2 The assembled Dewar pressure containment structure must be proof pressure tested to 1.5 times the maximum allowable working pressure per paragraph 5.1 of MIL-STD-1522A.

3.3.10.4.1 Launch Site Pressure Regulations

The Dewar pressure containment structure shall comply with the Centre Spatial Guyanais (CSG) range safety regulations as defined in CSG-RS-22A-CN, Specific Rules Spacecraft, vol. 2, part 2, paragraphs 3.2.2.3 and 4.2.2.2.

3.3.10.5 Fatigue life

Dewar structural parts shall have a fatigue life >4 lifetimes.

3.3.10.6 Galvanic Corrosion

Dewar Subsystem structural materials and coatings shall be selected for low susceptibility to galvanic corrosion of dissimilar materials per MIL-STD-889B.

3.3.10.7 Stress Corrosion Cracking

Dewar Subsystem metallic structural materials shall be selected for low susceptibility to stress corrosion cracking per NASA MSFC-STD-3029.

3.3.10.8 Fracture Control

In any Dewar structural part classified as “fracture critical” per NASA-STD-5003, the largest possible undetected flaw shall not grow to failure when subjected to the cyclic and sustained loads encountered in four (4) complete service lifetimes.

3.3.10.8.1 Non-Destructive Evaluation

Non-Destructive Evaluation (NDE) techniques shall be used to screen for flaws in fracture critical elements per MSFC-STD-1249 (Standard NDE Guidelines and Requirements for Fracture Control Programs).

3.3.10.8.2 Proof Load Testing for Fracture Critical Elements

Fracture critical elements shall be subjected to proof loads test at 1.0 times the limit level.

Note: Fracture critical elements are:

a) Dewars, lines, and fittings (per NASA-STD-5003, Fracture Control Requirements for Payloads Using the Space Shuttle)

b) Flexural kinematic mounts used to mount instruments provide, by definition, non-redundant load paths, and are therefore considered fracture critical for the purposes of this document.

c) Parts made of materials on Tables II or III materials, as documented in MSFC-STD-3029, Guidelines for the Selection of Metallic Materials for Stress Corrosion Cracking Resistance in Sodium Chloride Environments, if under sustained tensile stress.

d) All glass and ceramic elements stressed above 10% of their ultimate tensile strength shall be shown by fracture analysis to satisfy “safe-life” or “fail-safe” conditions or else shall be subjected to a proof loads test at 1.0 times the limit level.

3.3.10.8.3 Kinematic Mount - Analysis

The Kinematic Mount designs shall be analyzed using fracture mechanics (NASA/FLAGRO).

3.3.10.8.4 Kinematic Mounts - Test

3.3.10.9 NDE of Kinematic Mounts

The Kinematic Mount flight hardware shall be proof loaded and inspected for microcracks using NDE techniques.

Note: The Kinematic Mounts are to be tested separately from the Dewar.

3.3.10.10Stiffness of Kinematic Mounts

Principal stiffness of each Kinematic Mount (KM) design shall be verified by test.

3.3.10.11Strength Test Requirements:

All non-beryllium (this includes non-metallic composite and metal matrix structural elements) primary and secondary structural elements shall undergo a strength test to 1.25 x limit loads.

3.3.11 Maintainability

The Dewar Subsystem shall be designed to minimize maintenance during its ground operation and storage and shall require no maintenance during in-space operation.

3.3.11.1 Pre-Launch Autonomy

The Dewar shall accommodate a pre-launch autonomy period (launch hold) of 66 hours prior to launch, and a total of 88 hours non-venting in the event of a launch scrub.

3.3.11.2 Maintenance – Dewar Filling and Conditioning

The Dewar filling and conditioning operations shall be performed within a period of approximately one (1) week, with no continuous activities exceeding 24 hours, and ending prior to 66 hours before the second launch opportunity (or T-0 (launch 1) minus 42 hours).

Note: the final conditioning will occur with the JWST spacecraft (and Dewar) installed on the launch vehicle inside the fairing, through fairing payload access doors (see figure 3.3.11.2-1 for a cartoon of the configuration).

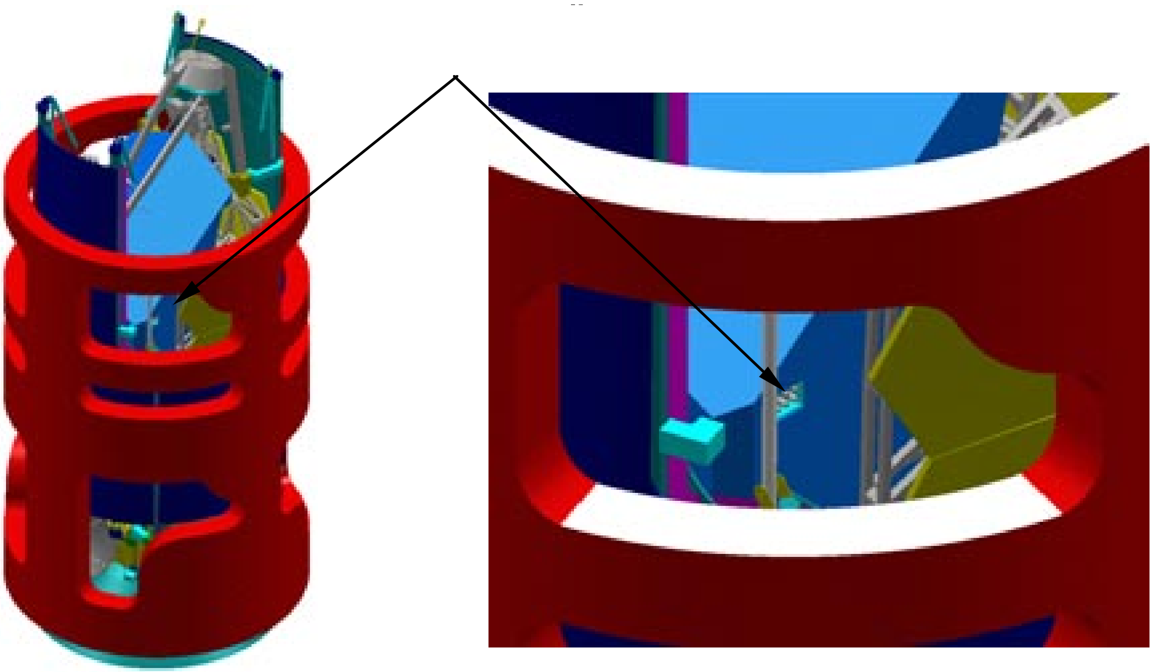


Figure 3.3.11.2-1. Cartoon of the access through the fairing to the Dewar servicing connections (arrows).

3.3.11.2.1 GSE Heaters

The cryogen tank(s) shall be equipped with GSE heaters or other devices to enable quick (TBD days) depletion of the flight cryogen during ground operations.

Note: In the event of a substantial launch delay after the Dewar has been filled, it may be necessary to empty the Dewar for safety reasons.

3.3.11.3 Preventive Maintenance

The Dewar Subsystem shall not require preventive maintenance beyond simple seal replacements.

3.3.11.3.1 Maintenance in Storage

The Dewar Subsystem shall require minimum maintenance to achieve the storage life specified in 3.2.2.5.2.

3.3.11.4 Corrective Maintenance

Wherever possible, the design of the Dewar Subsystem shall be directed toward minimizing the time required for corrective maintenance on the ground.

3.3.11.5 Testability

3.3.11.5.1 Design

The overall design of the Dewar shall be such that the Dewar can be developed, integrated and tested at module level with minimum interaction from the ISIM and MIRI or any other JWST equipment.

3.3.11.5.2 Accessibility

The Dewar design shall provide easy accessibility to connectors and equipment and shall allow for easy integration, removal and maintenance of all secondary structures, subsystems and equipment. In particular, the Dewar design shall allow for easy integration and removal of the thermal straps when the Dear and OBA are both installed within the ISIM.

3.3.11.5.3 Test Interfaces

Test points and integration and test (I&T) interfaces shall be accessible when the Dewar is mounted to the ISIM, and when the ISIM is mounted on the Observatory.

3.3.11.5.4 Leak Testing

The design shall be such as to make leak testing of the complete Dewar possible.

3.3.11.5.5 Electrical

The Dewar Subsystem shall provide access to signals via the primary interface connectors or optional test connectors to allow fault isolation between the Dewar Subsystem mechanical and electronics assemblies to the maximum extent possible.

3.3.11.6 Fault Diagnosis

To the extent reasonable, the Dewar Subsystem shall incorporate provisions for tracking the health of the Dewar Subsystem as it proceeds through the build, test, integration, and in-space operational phases. Particularly important parameters are those that are critical to operation or fault diagnosis, and are difficult to measure with external instrumentation. Examples include verification of the heat switch open and closed conductances, Dewar vacuum level, Dewar parasitic heat load for a standard set of interface temperatures, etc.

3.3.11.7 Interchangeability

The Dewar components shall be mechanically, thermally, and electrically interchangeable with any other Dewar component built to the same design.

3.3.12 Design Practices

3.3.12.1 Use of Metric Units

Dewar Subsystem weights and measures shall be expressed in metric system units per IEEE/ASTM SI-10, except where such use can be demonstrated to be impractical or likely to cause significant inefficiencies or loss of markets to U.S. firms.

3.3.12.2 Marking

Dewar Subsystem parts and assemblies shall be marked per FS500451, or JPL-approved equivalent.

3.3.12.2.1 Identification and Tagging

All items to be installed or removed prior to/following test, and all items to be installed or removed prior to flight, etc. shall be documented in the Instrument and Ground Support Equipment Packaging, Storing, Transport, and Handling Procedures (DRD-IT-07)

3.3.12.2.2 Red Tag – Flight

All items to be removed prior to flight shall be tagged with a red tag stating, “REMOVE BEFORE FLIGHT”.

3.3.12.2.3 Red Tag –Test

All items to be removed prior to test shall be tagged with a red tag stating, “REMOVE BEFORE TEST”

3.3.12.2.4 Green Tag – Flight

All items to be installed prior to flight shall be tagged with a green tag stating, “ADD BEFORE FLIGHT”

3.3.12.2.5 Green Tag – Test

All items to be installed prior to test shall be tagged with a green tag stating, “ADD BEFORE TEST”

3.3.12.3 Accessibility and Maintenance

3.3.12.3.1 Service Accessibility – ISIM Level

All items that are planned to be removed at the ISIM level shall be accessible without disassembly of the Dewar or removal of the Dewar from the ISIM

3.3.12.3.2 Service Accessibility – Dewar Component Level

All MIRI components (including the Dewar and DCE) shall be capable of being installed or removed during ground operations without degradation, damage or requiring re-certification of the flight hardware.

3.3.12.3.3 Test Instrumentation – Sensors

The MIRI shall accommodate temporarily installed sensors (e.g. acceleration sensors, thermal monitors, etc.) and supporting hardware, provided by the JWST Project, for purposes of monitoring during Instrument, ISIM, and Observatory ground testing.

3.3.12.3.4 Test Instrumentation – Sensor Location

Locations of the sensors shall be documented in the Dewar-MIRI ICD and delivered to JPL.

3.3.12.4 Design Margins

3.3.12.4.1 Margins on Heat loads

Margins on calculated heat loads of 30% shall be assumed on all Dewar heat loads during all phases of the mission (launch hold, launch, cool-down, operation). The heat lift requirements for the TSIs provided in section 3.2.3 have been margined and should not have any additional margin applied.

3.3.12.4.2 Margins on TSI Temperatures

The temperatures of the OA and FPM TSIs shall be calculated using all appropriate margined heat loads and applying a 100% margin (factor of 2) (TBR) to the thermal resistance linking the TSIs to the cryogen.

3.3.12.4.3 Cryogen sizing margins

The amount of cryogen shall be sized according to the margined heat load values calculated and given during the complete lifecycle of the Dewar. No additional margins shall be applied.

3.3.12.4.4 Mass margin definitions

Margin = Allocation – Current Best Estimate (CBE)

% Margin = (Margin/Allocation)*100

3.3.12.4.5 Mass Design Margins

The following design margins shall be applied in order to determine the Dewar mass for response to this RFP:

25%	New development or design
20%	Some design heritage
10%	Substantial design heritage
5%	Off the shelf hardware

Note: the margin used to calculate the mass of each component of the Dewar sub system shall be given in the RFP response.

Note: 5% mass margin is held at the MIRI system level.

3.3.13 Reliability and Redundancy

3.3.13.1 Single Fault Tolerance

The Dewar design shall be such that it will continue to provide cooling to both TSIs for the OBA following the failure of any single component.

3.3.13.2 Redundant Element Operation

Operation of all redundant elements shall be identified, so that operational paths are unambiguously known.

3.3.13.3 Single Point Failure Testing

All redundant and single point failures shall be tested and validated for all probable failure modes.

3.3.13.4 Heat Switch Failure Mode

The failure mode of the heat switch design shall be CLOSED.

3.3.13.5 Heat Switch Redundancy

The heat switches for each TSI shall be fully functionally redundant.

3.4 DEVELOPMENTAL MODELS

3.4.1 Engineering Test Unit Dewar

The Engineering Test Unit Dewar (ETUD) will be used in the ETU ISIM I&T Program during mechanical integration, vibration, acoustics, and cryo/vacuum testing. The ETUD is a thermal/mass simulator at the ISIM level.

3.4.1.1 Engineering Test Unit Dewar Interface Structure and Mounts

The Engineering Test Unit Dewar (ETUD) shall be a fully flight representative main structure and mounts with a mass dummy to simulate the cryogen mass load at launch.

3.4.1.1.1 ETUD/ISIM Mounting Geometry

The ETUD shall comply with the ISIM structure interface mounting geometry and methodology as documented in the Dewar-MIRI ICD

3.4.1.1.2 ETUD/Thermal Strap Interface

The ETUD shall comply with the defined mechanical and thermal strap mechanical interfaces as documented in the Dewar-MIRI ICD

3.4.1.1.3 ETUD Connector Interface Panel

The ETUD shall contain a flight representative connector interface panel(s) containing functional connector(s) for all cable/harness connections as documented in the Dewar-MIRI ICD

3.4.1.1.4 ETUD Connector Interface Panel Geometry

The ETUD connector interface panel(s) shall comply with the mounting geometry and methodology as documented in the Dewar-MIRI ICD

3.4.1.1.5 ETUD Handling Points and Hardware

The ETUD shall incorporate handling points and hardware as documented in the Dewar-MIRI ICD

3.4.1.1.6 ETUD Flight Design Tolerance

The ETUD shall replicate the flight design within the tolerances listed in Table 3.4.1.1.6-1.

Table 3.4.1.1.6-1. Tolerances

Parameter	Requirement
Mass	CDR Predicted Value +/- 0.5kg
Center of Gravity	CDR Predicted Value +/- 5mm
First Frequency	PDR Predicted Value +/- 5Hz (TBR)
Mount Hardware Thermal Conductance	PDR Predicted Flight Value +/- 5%
Radiated Heat Transfer (from/to instrument enclosure)	PDR Predicted Flight Value(s) +/- 20%
Total Power Dissipation plus Parasitic	PDR Predicted Flight Value +/- 5%

Heat to the SI	
Dewar Attachment Interface Point Coefficient of Thermal Expansion (CTE)	Same as Flight Unit

3.4.1.2 Engineering Test Unit Dewar Performance

3.4.1.2.1 ETUD Harness Connections

All harness connections shall be thermally and mechanically flight representative.

3.4.1.2.2 ETUD Thermal Signature

The ETUD shall incorporate cooling as required to provide the predicted thermal signature (steady-state interfaces) of the Flight Unit.

3.4.1.2.3 ETUD Thermal Monitoring/Telemetry Sensors

The ETUD shall incorporate thermal monitoring/telemetry sensors that are the same type/part as planned for use in the Flight Unit.

3.4.1.2.4 ETUD MLI

The ETUD shall include any external MLI needed for the Dewar to conform to thermal performance requirements.

3.4.1.2.5 ETUD External Surface Properties

The ETUD shall have flight representative external surface properties.

3.4.1.2.6 ETUD Certification

The ETUD shall be certified by the contractor as being capable of being subjected to the test environments (exposure limit and durations) as listed in Table 3.4.1.2.6-1.

Table 3.4.1.2.6-1. Environments

Environment	Exposure Limit	Duration
ISIM temperature during SI on-obit operation	27K (cold) to 37K (warm)	4 hours minimum (TBD)
Enclosure (radiative) temperature during SI on-orbit operation	25K (cold) to 40K (warm)	4 hours minimum (TBD)
ISIM temperature during SI operation, ambient temperation	313K (TBR)	4 hours minimum (TBD)
Enclosure (radiative)	313K (TBR)	4 hours minimum (TBD)

temperature during SI operation, ambient temperation		
ISIM temperature, on-orbit survival, SI off	22K (TBR)	4 hours minimum (TBD)
Enclosure (radiative) temperature, on-orbit survival, SI off	22K (TBR)	4 hours minimum (TBD)
Vibration	Qualification level (TBR)	TBR
Acoustics	Qualification level (TBR)	TBR

3.4.1.2.7 ETUD Pressure Vessel Safety

The contractor shall certify that the ETUD meets/complies with the GSFC pressure vessel safety requirements detailed at GSFC web site http://mscweb.gsfc.nasa.gov/549web/recert/recert.htm

3.4.2 Engineering Test Unit Fill and Drain System

The Engineering Test Unit (ETU) Fill and Drain System will be used in the ETU ISIM I&T Program during mechanical integration, vibration, acoustics, and cryo/vacuum testing.

3.4.2.1 ETU Fill and Drain System_Interface Structure and Mounts

3.4.2.1.1 ETU Fill and Drain System – Physical, Mechanical and Thermal

The ETU Fill and Drain system shall replicate the flight design mass, center of gravity, shall be representative of structural modes, and mechanical and thermal interfaces within the same tolerances as the ETUD.

3.4.2.1.2 ETU Fill and Drain System Mounting Geometry

The ETU Fill and Drain system shall comply with the Fill and Drain system mounting geometry and methodology as given in the Dewar-MIRI ICD.

3.4.2.2 ETU Fill and Drain System Performance

3.4.2.2.1 ETU Fill and Drain System – Coolant Flow

The ETU Fill and Drain system shall provide the requisite coolant flow/return for the ETU Dewar to replicate its thermal interfaces.

3.4.2.2.2 ETU Fill and Drain System – Certification

The ETU Fill and Drain system shall be certified by the contractor as being capable of being subjected to the test environments as given in Table 3.4.1.2.6-1 above.

3.4.3 Structural Thermal Model Vent System

The Structural Thermal Model (STM) Vent System will be used to validate the installation and mounting of the vent in the ISIM in the ETU ISIM I&T Program during mechanical integration, vibration, acoustics, and cryo/vacuum testing. The STM vent system is a mass simulator at the ISIM level.

3.4.3.1 STM Vent System Interface Structure and Mounts

3.4.3.1.1 STM Vent System – Physical, Mechanical and Thermal

The STM Vent shall be configured as a Structural Thermal Model that replicates the flight design mass, center of gravity, and mechanical interfaces within the tolerances in Table 3.4.1.1.6-1.

3.4.3.1.2 STM Vent System Mounting Geometry

The STM Vent shall comply with the Vent mounting geometry and methodology as given in the Dewar-MIRI ICD.

3.4.3.2 STM Vent System Performance

3.4.3.2.1 STM Vent System – Structural Modes

The STM Vent shall be representative of all structural modes below 100 Hz.

3.4.3.2.2 STM Vent System – Certification

The STM Vent shall be certified by the contractor as being capable of being subjected to the test environments as listed in Table 3.4.1.2.6-1.

3.4.4 Structural Thermal Model Dewar Control Electronics

The Structural Thermal **Dewar Control Electronics** (STMDCE) will be used in the ETU ISIM I&T Program during mechanical integration, vibration, acoustics, and cryo/vacuum testing.

3.4.4.1 STMDCE Interface Structure and Mounts

3.4.4.1.1 STMDCE – Physical, Mechanical and Thermal

The STMDCE shall be configured as a Structural Thermal Model that replicates the flight design mass, center of gravity, and mechanical and thermal interfaces within the tolerances in Table 3.4.1.1.6-1.

3.4.4.1.2 STMDCE – Structural Modes

The STMDCE shall be representative of all structural modes below 100 Hz.

3.4.4.1.3 STMDCE Connector Interface Panel

The STMDCE shall contain a flight representative connector interface panel(s) containing functional connector(s) for all cable/harness connections as given in the Dewar-MIRI ICD.

3.4.4.1.4 STMDCE Connector Interface Panel Geometry

The STMDCE connector interface panel(s) shall comply with the mounting geometry and methodology as given in the Dewar-MIRI ICD.

3.4.4.1.5 STMDCE Geometry

The STMDCE shall comply with the DCE mounting geometry and methodology as given in the Dewar-MIRI ICD.

3.4.4.2 STMDCE Performance

3.4.4.2.1 STMDCE Harness Connections

All harness connections shall be thermally and mechanically flight representative.

3.4.4.2.2 STMDCE Thermal Signature

The STMDCE shall incorporate heaters as required to provide the power dissipation of internal components.

3.4.4.2.3 STMDCE Thermal Monitoring/Telemetry Sensors

The STMDCE shall incorporate GSFC-provided temperature sensors for use in the thermal control circuitry.

3.4.4.2.4 STMDCE Thermal Control

The STMDCE shall incorporate radiators, thermal coatings, and MLI with effective emmitance and other key thermo-optical properties similar to those of the flight unit.

3.4.4.2.5 STMDCE Certification

The STMDCE shall be certified by the contractor as being capable of being subjected to the test environments (exposure limit and durations) as listed in Table 3.4.1.2.6-1.

4 QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Quality Assurance

Primary responsibility for quality assurance of delivered hardware, processes, tests, or services is placed on the supplier, who is responsible for offering only those hardware, processes, tests, or services that conform to specified requirements. The contractor shall implement a quality assurance program to assure that the requirements of this specification are met.

4.2 Quality Conformance Inspections and Tests

The requirements of Section 3 shall be verified by one or more of the following methods (Methods subject to revision) as outlined in Table 4.2-1:

1. Inspection (I). A visual observation, examination, or direct measurement of the physical characteristics of the deliverable item with a comparison to the applicable requirement.
2. Analysis (A). A prediction showing that the deliverable hardware complies with the stated requirements based on measured properties, including component-level development test data, together with analytical models based on the applicable engineering and physical governing equations.
3. Flight Analysis (FA). A prediction showing that the proposed flight hardware design would comply with the stated requirements based on component-level development test data and inspections together with analytical models based on the applicable engineering and physical governing equations. However, the STM, or ETU deliverable hardware need not satisfy the requirement. (TBR)
4. Test (T). The direct measurement of applicable parameters during operation of the deliverable item under controlled conditions with test inputs and sufficient instrumentation to provide quantitative data that are directly compared to prescribed requirements.
5. Engineering Test (ET). The direct measurement of applicable parameters during operation of the deliverable Dewar with EM electronics. This test is not applicable for the ETU Dewar with BE.
6. Design Review (D). The determination that the requirement is met by examining the detailed design of the deliverable component or subassembly by independent technical experts not directly involved in the design itself.
7. Flight Design Review (DF). The determination that the proposed flight hardware design would comply with the stated requirements based on examination of the proposed flight design of the component or subassembly by independent technical experts not directly involved in the design itself. However, the EM or BE deliverable hardware need not satisfy the requirement.

4.3 Test Documentation and Equipment

4.3.1 Test Documentation

Prior to the conduct of any testing called for by this specification, the contractor shall prepare a test procedure including the testing sequence, the test methods, and the pass/fail criteria for each test. The test procedure shall be submitted to JPL for approval prior to testing. Complete records of all tests shall be kept and made available to JPL. The records shall include the data for each test conducted. A JPL representative shall be notified of test dates so that tests may be witnessed by JPL.

Requirements	Articles	Verifications						
		Engineering Model (EM)				Breadboard Electronics (BE)	EGSE	Applicable Verification
			Mechanical		Electronics			
3.	**REQUIREMENTS**	–	–	–	–	–	–	–
	(TO BE FILLED IN AS PART OF THE RESPONSE TO THE RFP)							

Articles / Requirements		Verifications						
		Engineering Model (EM)				Breadboard Electronics (BE)	EGSE	Applicable Verification
			Mechanical		Electronics			

4.3.2 Test Equipment Accuracies

Unless otherwise agreed to, equipment used to measure unit parameters shall not introduce an error greater than ten percent of the tolerance of the parameter being measured.

4.4 DEWAR SUBSYSTEM DESIGN AND VERIFICATION PROGRAM

The following verification tests and analyses listed in Table 4.2-1 shall be used, in combination with Design Reviews and Inspections if applicable, to verify the requirements of Section 3. Items marked with an asterisk (*) are only applicable to the EM electronics and are not applicable to the BE.

4.4.1 Digital Communication and Software Functionality Test

A Digital Communication and Software Functionality Test shall be conducted to verify the digital interface and control functionality of the Dewar Control Electronics and EGSE with respect to paragraphs given in Table 4.4.1-1. The capability of the Dewar Subsystem to implement all applicable modes of operation specified in 3.1 shall be verified.

Table 4.4.1-1. Specification paragraphs verified by the Digital Communication and Software Functionality Test.

Paragraph #	Description
3.#.#.#.#.#	(To be filled in as part of the response to the RFP)

4.4.2 Thermal Vacuum and Refrigeration Performance Test

A system-level test of the entire Dewar Subsystem shall be conducted using the ‘flight’ cryogen to verify conformance to the refrigeration performance, power consumption and heat rejection interface requirements defined in the paragraphs given in Table 4.4.2-1. Capability to survive TBD thermal cycles to Protoflight non-operating temperatures may be demonstrated at the assembly level (TBD). The cryogenic heat loads shall be applied by means of heaters mounted on the thermal masses that are attached to the Thermal Strap Interfaces. Care shall be taken to quantify any cryogenic heat load contributions associated with TSIs radiation and structural-support parasitics.

Prior to the system-level thermal tests, subsystem and assembly level tests shall be performed. Assemblies of the Dewar subsystem include all functional entities as large as the cryogen tank(s), and the vacuum vessel, and as small as heat switches, heaters, thermal shields, and the DCE. The assembly-level thermal environmental tests also includes all specialized thermal cycling tests and thermal shock tests at the proper level of assembly (e.g., the LN2 immersion tests at the subassembly (tank, DVV) level). This also includes validating the filling operation.

4.4.2.1 Prerequisites

4.4.2.1.1 Proof Pressure and Associated Electrical and Mechanical Tests

Proof pressure tests and other mechanical and electrical tests shall have been performed before proceeding with this Dewar subsystem thermal vacuum test of the Dewar in flight-like environment.

4.4.2.1.2 Leak-Tightness of the Flight Dewar Subsystem

A leak check shall be preformed for the complete test setup using helium as a leak detecting medium before the start of Dewar subsystem thermal vacuum test (at ambient (~293K) temperature). This includes the full test setup including all GSE, vent and fill connections and all mechanical and electrical interfaces. The total system leak rate shall not exceed $1X10^{-7}$(TBR) standard cc/hour of helium.

4.4.2.1.3 Dewar Subsystem Hot Survivability Test

The dewar subsystem hot survivability test at 320 K must have been separately and successfully completed in accordance with TBD above. This could have been combined with the bakeout test for decontamination certification.

4.4.2.1.4 Test Thermal Math Model of the Dewar Subsystem and Interfaces

In addition to the thermal math model (TMM) used for the thermal analysis and thermal design of the Dewar subsystem, a test thermal math model (TTMM) shall be constructed to predict the performance of the Dewar subsystem in this thermal vacuum test. The TTMM shall be “test-like” and include all Dewar subsystem hardware, interfaces, and test support equipment:

In particular, all potential background heat sources:

- Conduction via struts and cables
- Radiation from the outershell
- Conduction via all fill and vent lines
- Radiation from adjacent hardware
- Conduction via utility penetrations
- Convection, if any
- Power dissipations

shall be included. Dewar thermal vacuum test shall not start before this TTMM, its temperature predictions, and the background heat source predictions have been reviewed and approved by the contractor and JPL.

4.4.2.2 Dewar Subsystem Thermal Vacuum Test Requirements

(Note: This subsystem thermal vacuum test is in addition to the outgassing test performed at higher temperature under the Dewar subsystem contamination control plan.)

4.4.2.2.1 Test Configuration

The configuration of the test article shall be flight-like. This includes all Dewar assemblies, all elements of the plumbing subsystem, the DCE, cable harness, wiring, controls, all accessories, and all test GSE. This also includes surrogate thermal straps attached to the thermal strap interfaces.

The tank(s) shall be filled with solid hydrogen or a surrogate substance as deemed proper by the contractor and JPL. The FPM and OA can be simulated by equivalents with equal mass and steady state and transient thermal characteristics and the capabilities of heat load control.

4.4.2.2.2 Test Media

The test chamber environment shall be vacuum (chamber pressure at 10^{-5} torr or lower).

4.4.2.2.3 Test Objectives

The objectives of this test are:

1. To verify that the Dewar subsystem is leak-tight. This includes the vacuum vessel, the tank(s), all vent and fills, and all interfaces.
2. To verify that the background heat sources are as predicted by the TTMM.
3. To verify that the Dewar subsystem cools down as predicted by the TTMM.
4. To verify that the thermal control performs satisfactorily and to conduct a thermal balance test to confirm heat flows and to collect thermal data for the final correlation of the thermal model for flight predictions.
5. To verify that the dewar subsystem meets all functional, operational, and control performance requirements under simulated mission conditions as specified in TBD (see table 4.4.2-1 below). This includes the rate of consumption of the cryogen in accordance with the prediction by the TTMM.
6. To calibrate all flight temperature sensors.
7. To demonstrate that the Dewar subsystem meets the performance specification with ample thermal margins.

4.4.2.2.4 Interface Simulation (External Environmental Simulation)

The thermal interfaces during steady state portions of the test shall be simulated according to Table 4.4.2.2.4-1 below:

Table 4.4.2.2.4-1. Thermal Interfaces and Stability

No.	Assembly	Test Temps (Note 3)	Heat Flux or Heat Dissipation	Rate of Change
Conduction				
1	Fill and Vent Valves and Piping	310 K	Note 1	TBD
2	Mech. Mounts and Piping (simulating ISIM)	37 K	Note 1	0.2 K/min
3	DCE Heat Sink	310 K	6 watts	0.2 K/min
4	FPM Thermal Strap I/F	6.65 K	4.7 mw	0.5 mw/1000sec
5	OA Thermal Strap I/F	7.6 K	55.3 mw	5.0 mw/1000sec
6	Electrical Harness	Note 1	Note 1	Note 1
Thermal Radiation				
7	Chamber Shrouds (simulating ISIM w/emitt. = 0.7)	40 K	Note 1	TBD
Convection				
8	Residual Gases, if any	Note 1	Note 1	Note 1
9	Sublimation of SH2 or evaporation of substitute cryogen	Note 2	Note 2	Note 2

Notes:
(1) As calculated by the TTMM.
(2) As measured in the test.
(3) These are either the hot or cold worst case of mission operations.

4.4.2.2.5 Simulation of the Internal Heat Dissipations

Max. DCE heat dissipation (6 watts) shall be simulated in this test. Heat dissipation in the control wirings and control devices shall be flight-like in this test.

4.4.2.2.6 Test Cases

As a minimum, four (4) test cases shall be included in this test:

Case 1: Cooldown Characterization Case

Case 2: Refrigeration Performance Verification Case (Shroud at 35 °K)

Case 3: Subsystem Thermal Margin Demonstration No. 1 (Shroud at 45 °K)

Case 4: Subsystem Thermal Margin Demonstration No. 2 (Shroud at 55 °K)

Case 1 is for the characterization of the Dewar subsystem cooldown. The test duration for this case is “as required” for the collection and recording of cooldown data. The demonstration of the full cooldown period is not required. Accelerated cooldown (non-flight like) methods can be used as deemed proper by the test conductor but should be in agreement with the TTMM predictions. Thermal pre-conditioning is acceptable.

Case 2 is for the verification of dewar subsystem performance under mission operating condition in accordance with the requirements in Section 3. Cases 3 and 4 shall demonstrate the reliability and thermal environmental margins of the Dewar subsystem.

Chamber breaks between test cases can be added as determined to be necessary by the test conductor. Test cases which have been performed before the chamber breaks need not be repeated.

4.4.2.2.7 Performance Verification

As a minimum, the following performance shall be verified in accordance with the paragraphs in this specification as given in Table 4.4.2.2.7-1.

4.4.2.2.8 Test Profiles

The temperature-time test profiles of this test are shown in Figure 4.4.2.2.8-1. It includes the required key temperature levels and the definition of thermal equilibrium for this test. The test profile for retest is the same except that Case 3 and Case 4 need not be performed.

4.4.2.2.9 Thermal Math Model (TMM) Correlation and Final Flight Prediction

The subsystem TMM shall be correlated with the test data collected from this test. The correlated TMM shall be used to make the final mission performance predictions of the Dewar subsystem.

4.4.2.2.10 Retest Requirements

If a retest of the Dewar becomes necessary, the re-qualification test shall be accomplished by performing an acceptance test with a test profile shown in Figure 4.4.2.2.8-1.

Table 4.4.2.2.7-1. Specification paragraphs verified by the Thermal Vacuum and Refrigeration Performance Test.

Paragraph #	Description
3.#.#.#.#.#	(To be filled out as part of the response to the RFP)

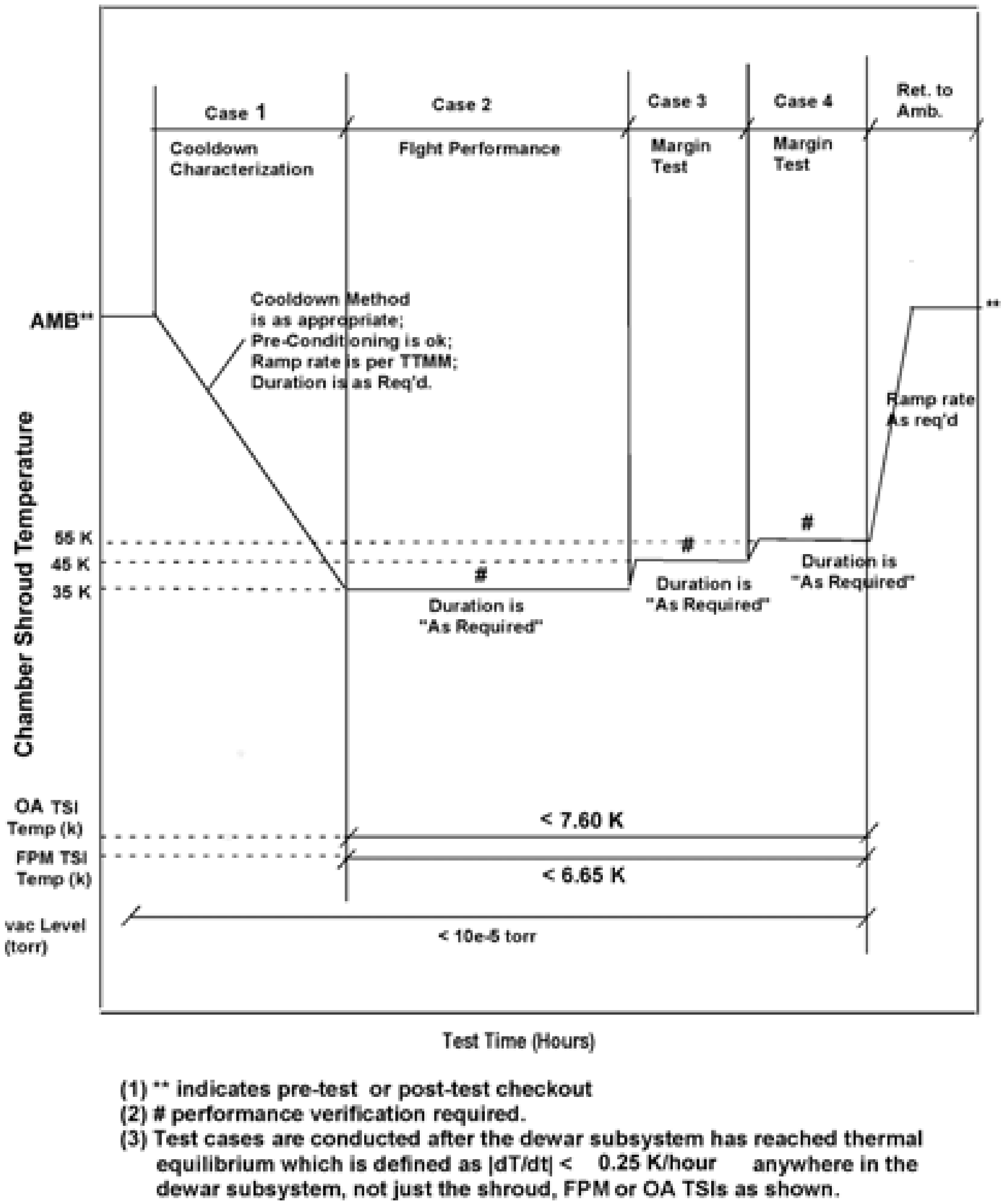


Figure 4.4.2.2.8-1. Dewar Thermal Vacuum Test Profile (Retest profile is the same except that the 45 K and 55 K test cases need not be performed)

4.4.3 Temperature Control and Stability Test

A system-level test of the entire Dewar Subsystem shall be conducted to verify conformance to the Temperature Sensors and Control and Temperature Stability requirements defined in paragraphs given in Table 4.4.3-1 as follows: (note: may be performed as part of the Thermal Vacuum and Refrigeration Test in section 4.4.2)

Table 4.4.3-1. Specification paragraphs verified by the Temperature Control and Stability Test.

Paragraph #	Description
3.#.#.#.#.#	(To be filled out as part of the response to the RFP)

4.4.4 Electrical Power Interface and EMI Test

Tests shall be conducted to verify conformance to the electrical interface and EMI requirements defined in paragraphs given in Table 4.4.4-1. For these tests the Dewar Subsystem shall be driven from a dc voltage supply with the source impedance characteristics identified in TBD. EMI tests shall be conducted in accordance with the methods of MIL-STD-462 as listed below. For those tests conducted in accordance with the methods of MIL-STD-462, the requirements of the referenced paragraphs of this specification shall govern rather than the values listed in MIL-STD-462. Items marked with an asterisk (*) are only applicable to testing the TBD electronics.

Table 4.4.4-1. Specification paragraphs verified by the Electrical Power Interface and EMI Test.

Paragraph #	Description
3.#.#.#.#.#	(To be filled out as part of the response to the RFP)

4.4.5 Launch Vibration Test

Launch vibration tests shall be conducted on each Dewar Subsystem assembly at the Protoflight level in all three axes to verify conformance of the individual Dewar Subsystem assemblies to the requirements defined in paragraphs given in Table 4.4.5-1. Functional performance and working-fluid leak rate shall be measured before and after the launch vibration test sequence on each assembly.

Table 4.4.5-1. Specification paragraphs verified by the Launch Vibration Test.

Paragraph #	Description
3.#.#.#.#.#	(To be filled out as part of the response to the RFP)

4.4.6 Life Analysis

A thorough analysis showing compliance with the EOL requirements of paragraphs given in Table 4.4.6-1 shall be performed based on component-level development and life test data, comparison with system life test data on analogous hardware, and analytical models based on the applicable engineering and physical governing equations. Specific elements of the analysis shall address the following requirements:

Table 4.4.6-1. Specification paragraphs verified by the Life Analysis.

Paragraph #	Description
3.#.#.#.#.#	(To be filled out as part of the response to the RFP)

4.4.7 Structural Analysis

A thorough analysis showing compliance with the structural and safety requirements of paragraphs given in Table 4.4.7-1 shall be performed based on component-level finite element modeling, assembly-level test data, and other analytical models based on the applicable engineering and physical governing equations. Specific elements of the analysis shall address the requirements listed below. With respect to the pressurized components requirements, the contractor shall conduct qualification testing as specified in the applicable paragraphs of Section 5.1 of MIL-STD-1522 and shall demonstrate that the Dewar Subsystem meets a proof test of 1.5 times the maximum allowable working pressure. These data may be acquired as part of the mechanical assembly build data.

Table 4.4.7-1. Specification paragraphs verified by Structural Analysis.

Paragraph #	Description
3.#.#.#.#.#	(To be filled out as part of the response to the RFP)

4.4.8 Electronic Packaging Analysis

An analysis showing compliance with the electronic packaging structural/thermal requirements given in Table 4.4.8-1 shall be performed based on component-level development and thermal-cycle life test data, comparison with the measured performance of analogous hardware, and analytical models based on the applicable engineering and physical governing equations. Specific elements of the analysis shall address the following requirements. Items marked with an asterisk (*) are only applicable to the TBD electronics.

Table 4.4.8-1. Specification paragraphs verified by Electronics Packaging Analysis.

Paragraph #	Description
3.#.#.#.#.#	(To be filled out as part of the response to the RFP)